Appendix A

Assessment Results by Hydrologic Region

Appendix A

Assessment Results by Hydrologic Region

This appendix contains results of the hydropower assessments of the 20 hydrologic regions of the United States. The regional results are presented in Table A-0[a] to facilitate lookup of hydropower potential values and comparison of these values amongst the regions. This summary information is followed by 20 sections, each devoted to a particular region. Each section has the same format, which includes a description of the geographic features of the region and a table listing hydropower potential values by power class and category (total, developed, excluded, and available). The data in the table are presented in a series of pie charts to graphically illustrate the distributions of power potentials by power category and hydropower technology class. The section concludes with maps showing the locations of existing hydroelectric plants and low power potential sites in the region.

The results presented in this appendix do not include any assessment of the feasibility of developing or the actual availability for development of any water energy resources. The term "available" used in the tables and figures in this appendix only denotes the net amount of power potential after subtracting the amounts of developed and excluded power potential from the gross amount of power potential.

A.1 North Atlantic Region

A.1.1 Region Description

The topographic and hydrographic features of the North Atlantic Region are shown in Figure A-1. The North Atlantic Region covers most or all of the following New England states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. The New England Upland, a northern extension of the Appalachian Mountains, occupies the inland portion of the North Atlantic Region. The New England Upland consists of wooded mountains, many of which reach several thousand feet in elevation. The remainder of the region, the Seaboard Lowland, is a series of coastal plains and rolling low hills between the mountains and the sea. In Maine, rolling hills directly border the Atlantic Ocean, forming a rugged, irregular shoreline of alternating bays, peninsulas, and islands.

The Connecticut River is the principal river in the North Atlantic Region. It flows southward, forming the boundary between New Hampshire and Vermont before crossing Massachusetts and Connecticut where it discharges into Long Island Sound. Other major rivers in the region include the St. John and Penobscot Rivers in Maine.

The climate is humid continental. Warm summers and cold winters are found in the south, while cool summers and severe winters dominate the northern interior. Coastal regions are subject to marine influence, including severe winter storms from the North Atlantic Ocean (nor'easters) and the possibility of tropical storms or hurricanes in the summer.

A.1.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power

a. The United States and some regional total, excluded, and available potentials in this table are 1–4% higher than the more accurate values listed in a corresponding table in Appendix B. This is because of the more discriminating state boundaries GIS layer used compared to that for the region boundaries. These inaccuracies should have little effect on the percentage values listed in the lower part of the table. The sum of the state hydropower potentials in the various categories and power classes have been used as the official estimates for the United States.

fractions of the total available power potential (annual mean power)

- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

Table A-0. Summary of regional water energy resources power potentials (annual mean power) and percentages of totals by category and power class.

		Total Potential				Available Potential			Available Low Head/Low Power Potential		
HUC #	Name	Total (MW)	Developed (MW)	Excluded (MW)	Available (MW)	High Power (MW)	High Head/ Low Power (MW)	Low Head/ Low Power (MW)	Conventional Turbines (MW)	Unconventional Systems (MW)	Microhydro (MW)
1	North Atlantic	5,659	872	223	4,564	2,940	1,091	533	189	78	266
2	Mid-Atlantic	9,254	840	798	7,616	4,672	1,959	985	387	133	465
3	South Atlantic-Gulf	8,661	1,850	453	6,358	3,366	738	2,254	743	507	1,004
4	Great Lakes	4,353	2,852	271	1,230	0	573	657	80	132	444
5	Ohio	12,109	820	1,275	10,014	7,252	1,219	1,543	565	208	770
6	Tennessee	5,075	1,859	743	2,473	1,434	638	401	143	64	194
7	Upper Mississippi	5,766	404	630	4,732	3,135	224	1,373	458	293	622
8	Lower Mississippi	12,418	136	835	11,447	10,612	97	738	209	213	316
9	Souris Red-Rainy	431	12	101	318	108	45	165	48	22	95
10	Missouri	15,823	1,797	4,622	9,404	4,752	1,846	2,806	1,090	340	1,376
11	Arkansas-White-Red	5,053	696	329	4,028	1,535	694	1,799	721	329	749
12	Texas Gulf	1,811	127	61	1,623	363	193	1,067	320	179	568
13	Rio Grande	2,122	50	602	1,470	376	530	564	159	78	327
14	Upper Colorado	9,489	723	2,692	6,074	4,062	1,402	610	188	89	333
15	Lower Colorado	3,452	789	931	1,732	562	607	563	171	42	350
16	Great Basin	3,043	97	452	2,494	942	973	579	123	24	432
17	Pacific Northwest	76,440	16,644	20,009	39,787	31,691	6,290	1,806	626	254	926
18	California	26,953	4,668	12,042	10,243	7,683	1,913	647	195	77	375
19	Alaska	91,797	171	41,347	50,279	41,909	5,711	2,659	907	407	1,345
20	Hawaii	2,304	20	459	1,825	1,682	134	9	1	0	8
	U.S. Total	**302,013**	**35,427**	**88,875**	**177,711**	**129,076**	**26,877**	**21,758**	**7,323**	**3,469**	**10,965**

HUC #	Name	Total[a]	Developed[b]	Excluded[b]	Available[b]	High Power[c]	High Head/ Low Power[c]	Low Head/ Low Power[c]	Conventional Turbines[d]	Unconventional Systems[d]	Microhydro[d]
1	North Atlantic	**2%**	**15%**	4%	**81%**	64%	**24%**	12%	**35%**	15%	**50%**
2	Mid-Atlantic	**3%**	9%	9%	**82%**	61%	**26%**	**13%**	**39%**	14%	47%
3	South Atlantic-Gulf	**3%**	**21%**	5%	**73%**	53%	12%	**35%**	33%	**22%**	45%
4	Great Lakes	**1%**	**66%**	6%	28%	0%	**47%**	**53%**	12%	**20%**	**68%**
5	Ohio	**4%**	7%	11%	**83%**	**72%**	12%	**15%**	**37%**	13%	**50%**
6	Tennessee	**2%**	**37%**	15%	49%	58%	**26%**	**16%**	**36%**	**16%**	48%
7	Upper Mississippi	**2%**	7%	11%	**82%**	66%	5%	**29%**	33%	**21%**	45%
8	Lower Mississippi	**4%**	1%	7%	**92%**	**93%**	1%	6%	28%	**29%**	43%
9	Souris Red-Rainy	**0%**	3%	23%	**74%**	34%	14%	**52%**	29%	13%	**58%**
10	Missouri	**5%**	11%	**29%**	**59%**	51%	**20%**	**30%**	**39%**	12%	49%
11	Arkansas-White-Red	**2%**	**14%**	7%	**80%**	38%	**17%**	**45%**	**40%**	**18%**	42%
12	Texas Gulf	**1%**	7%	3%	**90%**	22%	12%	**66%**	30%	**17%**	**53%**
13	Rio Grande	**1%**	2%	28%	**69%**	26%	**36%**	**38%**	28%	14%	**58%**
14	Upper Colorado	**3%**	8%	28%	**64%**	67%	**23%**	10%	31%	15%	**55%**
15	Lower Colorado	**1%**	**23%**	27%	50%	32%	**35%**	**33%**	30%	7%	**62%**
16	Great Basin	**1%**	3%	15%	**82%**	38%	**39%**	**23%**	21%	4%	**75%**
17	Pacific Northwest	**25%**	**22%**	26%	52%	**80%**	**16%**	5%	**35%**	14%	**51%**
18	California	**9%**	**17%**	**45%**	38%	**75%**	**19%**	6%	30%	12%	**58%**
19	Alaska	**30%**	0%	**45%**	55%	**83%**	11%	5%	**34%**	15%	**51%**
20	Hawaii	**1%**	1%	20%	**79%**	**92%**	7%	0%	11%	0%	**89%**
	U.S. Average		**12%**	**29%**	**59%**	**73%**	**15%**	**12%**	**34%**	**16%**	**50%**

a. Regional percentage of total United States hydropower potential
b. Percentage of regional total hydropower potential
c. Percentage of regional total available hydropower potential
d. Percentage of regional total low head/low power hydropower potential

Note 1: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.
Note 2: The United States total, excluded, and available potentials listed are 1–4% higher than in the corresponding table in Appendix B, which contains more accurate United States values.
Note 3: Bolded figures indicate values greater than or equal to the United States average.
Note 4: Blue background indicates constituent with the largest percentage.
Note 5: Numbers in yellow font indicate adjusted values due to redistribution of developed potential in the high head/high power power class to these power classes. See Subsection 3.6.2.

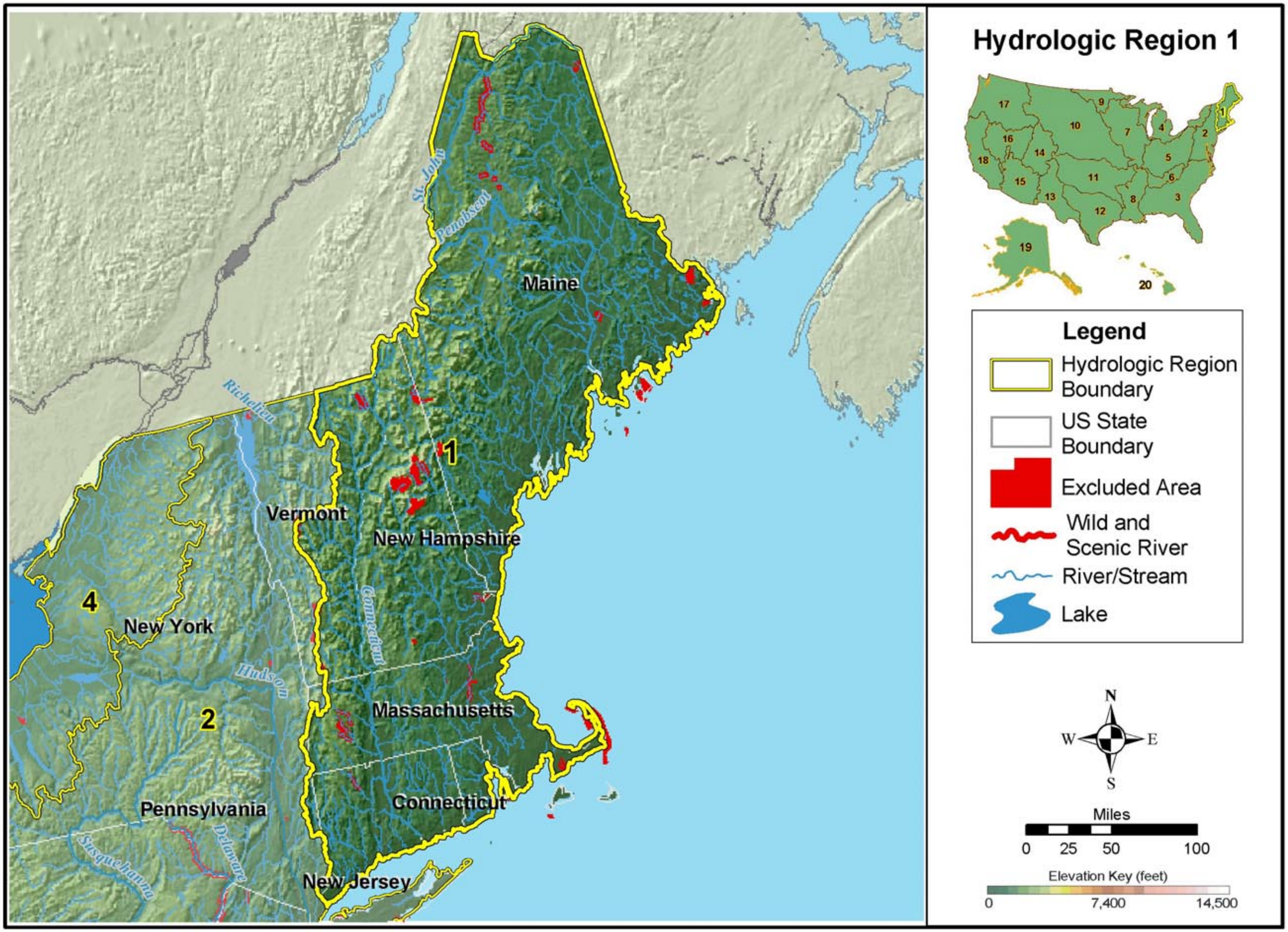

Figure A-1. North Atlantic Region (HUC 1).

Table A-1. Summary of results of water energy resource assessment of the North Atlantic Region (HUC 1).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**5,659**	**872**	**223**	**4,564**
TOTAL HIGH POWER	**3,875**	**798**	**137**	**2,940**
High Head/High Power	**2,768**	**656**	**112**	**2,000**
Low Head/High Power	**1,107**	**142**	**25**	**940**
TOTAL LOW POWER	**1,784**	**74**	**86**	**1,624**
High Head/Low Power	**1,192**	**33**	**68**	**1,091**
Low Head/Low Power	**592**	**41**	**18**	**533**
Conventional Turbine	234	38	7	189
Unconventional Systems	83	0	5	78
Microhydro	275	3	6	266

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

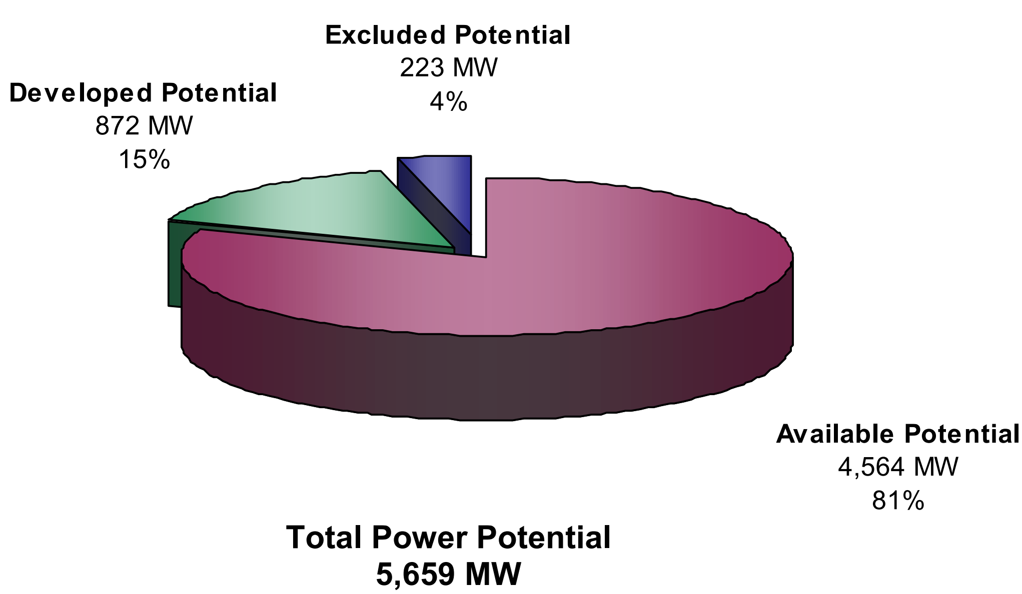

Figure A-2. Power category distribution of the total power potential (annual mean power) of water energy resources in the North Atlantic Region (HUC 1).

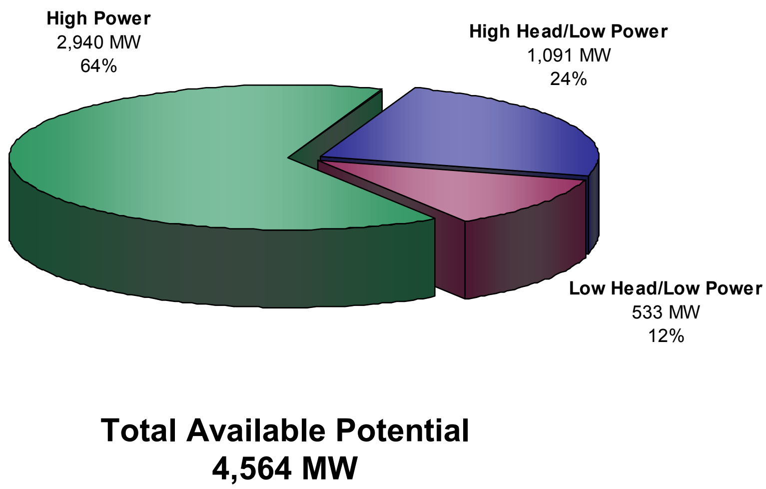

Figure A-3. Power class distribution of the available power potential (annual mean power) of water energy resources in the North Atlantic Region (HUC 1).

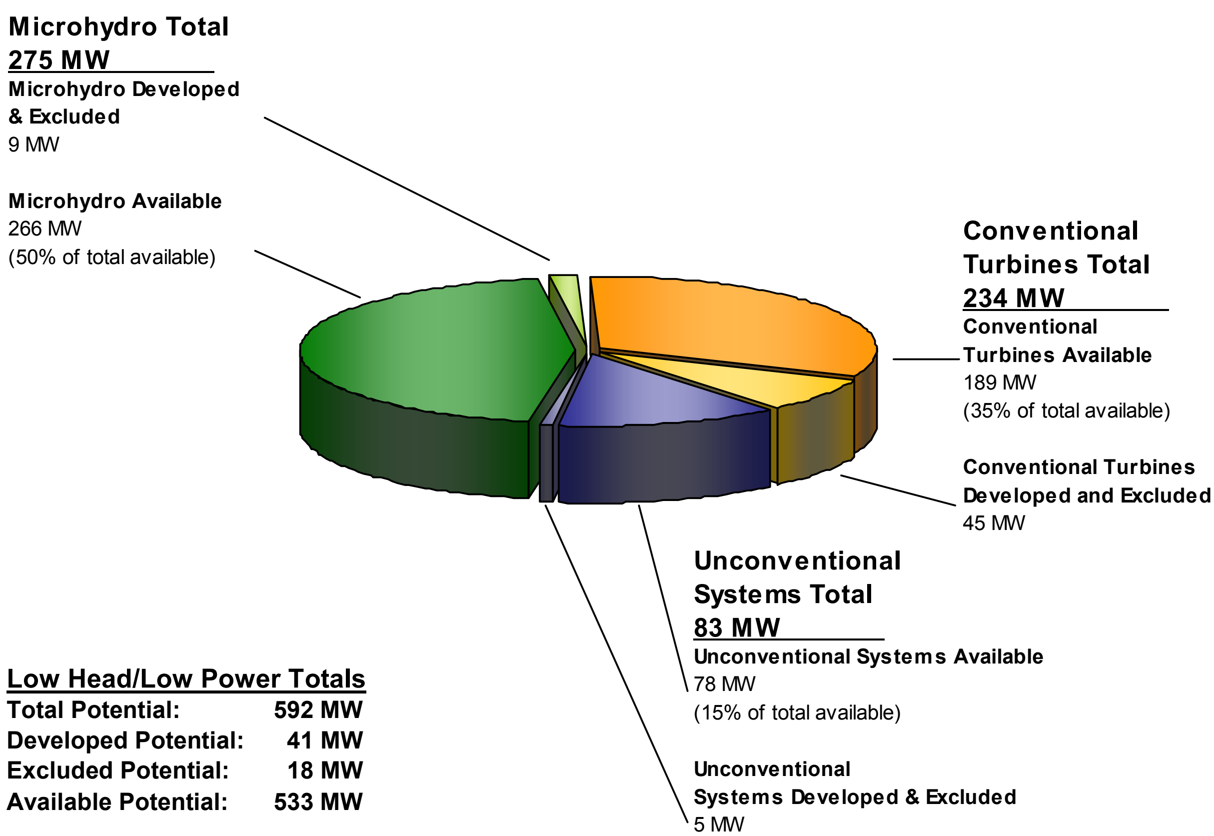

Figure A-4. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the North Atlantic Region (HUC 1) among three low head/low power hydropower technology classes.

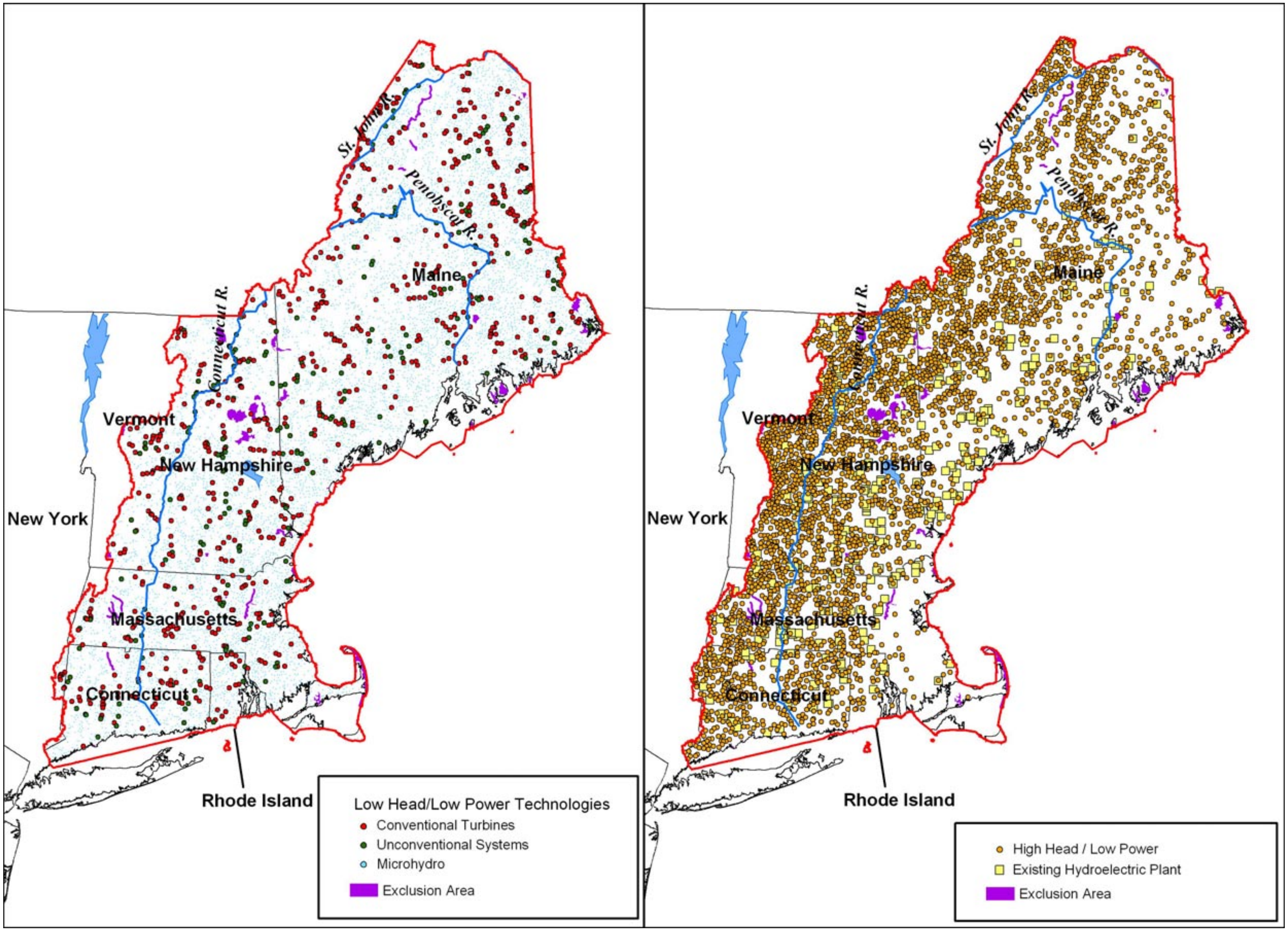

Figure A-5. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the North Atlantic Region (HUC 1).

A.2 Middle Atlantic Region

A.2.1 Region Description

The topographic and hydrographic features of the Middle Atlantic Region are shown in Figure A-6. The Middle Atlantic Region covers approximately half of the States of Vermont, New York, and Pennsylvania, the entirety of the states of New Jersey and Delaware, most of the State of Maryland, and parts of the States of Virginia and West Virginia. The principal geographic features of this region (from east to west) are the Atlantic Coastal Plain, the Piedmont, and the Appalachian Mountains. Inland from the Atlantic Coastal Plain lies the Piedmont, a relatively low, rolling plateau that extends the entire length of the Middle Atlantic Region. The Piedmont is a fertile agricultural region crossed by many rivers originating in the Appalachian Mountains. The Piedmont rises to meet the Appalachians, a major mountain chain that runs from Maine to Alabama. A principal feature of the Appalachian Mountains from New York state southward is the ridge and valley sequence, a northeast-trending series of alternating ridges and valleys formed by the folding and erosion of parallel rock layers.

Several major rivers originate in the Appalachians, flowing across the Piedmont to bays and inlets on the Atlantic coast. These include (from north to south) the Hudson River, the Delaware River, the Susquehanna River, and the Potomac River. Many of these rivers are navigable and provided some of the earliest transportation corridors from the eastern United States to the interior of North America.

The climate of the region is temperate with abundant rainfall throughout the year. Temperatures are moderate near the southern coastal areas of the region, becoming cooler as one travels northward toward New York or inland from the coast.

A.2.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

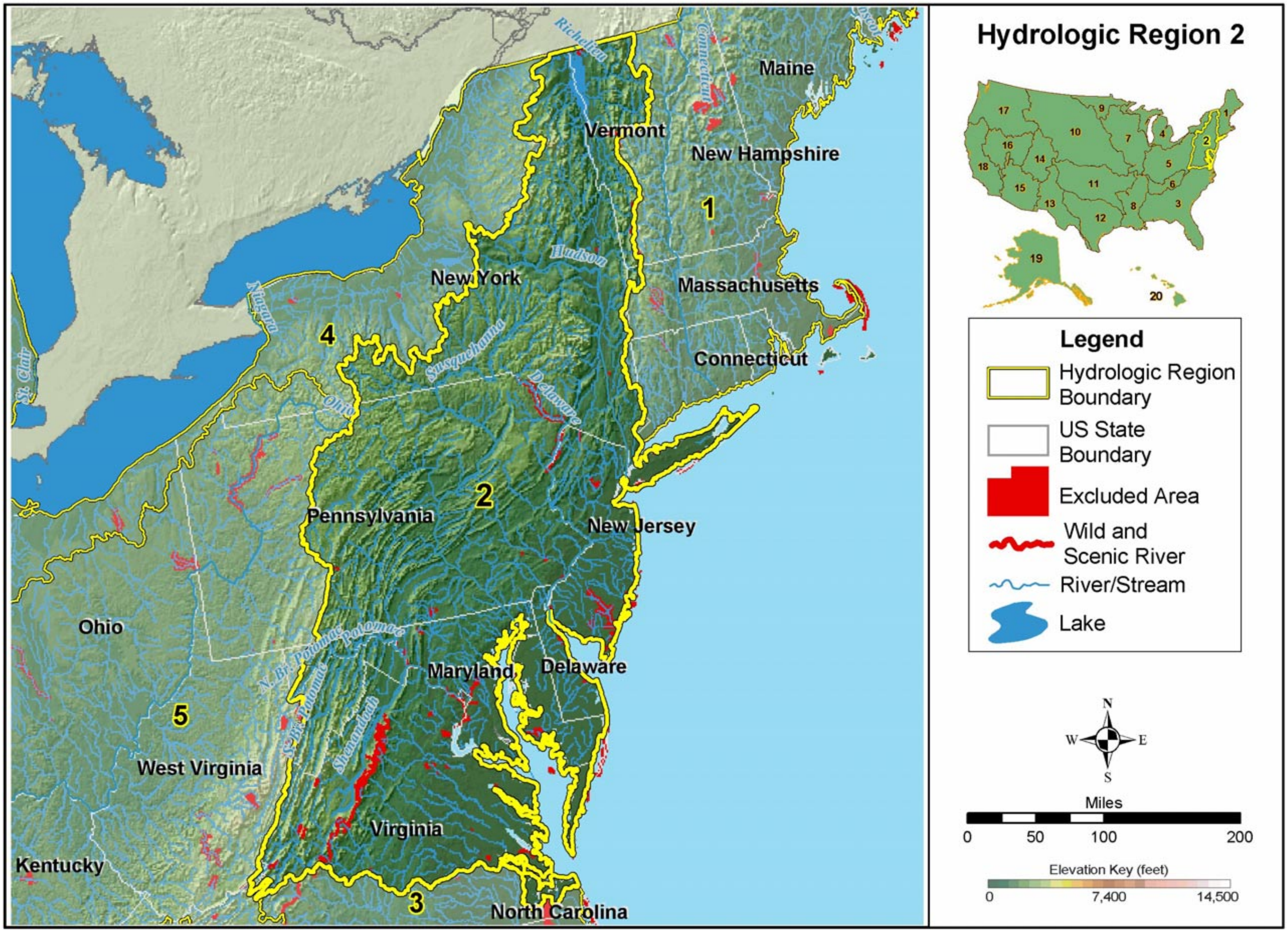

Figure A-6. Middle Atlantic Region (HUC 2).

Table A-2. Summary of results of water energy resource assessment of the Middle Atlantic Region (HUC 2).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**9,254**	**840**	**798**	**7,616**
TOTAL HIGH POWER	**6,147**	**801**	**674**	**4,672**
High Head/High Power	**3,827**	**732**	**312**	**2,783**
Low Head/High Power	**2,320**	**69**	**362**	**1,889**
TOTAL LOW POWER	**3,107**	**39**	**124**	**2,944**
High Head/Low Power	**2,073**	20	94	1,959
Low Head/Low Power	**1,034**	19	30	985
Conventional Turbine	415	18	10	387
Unconventional Systems	139	0	6	133
Microhydro	480	1	14	465

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

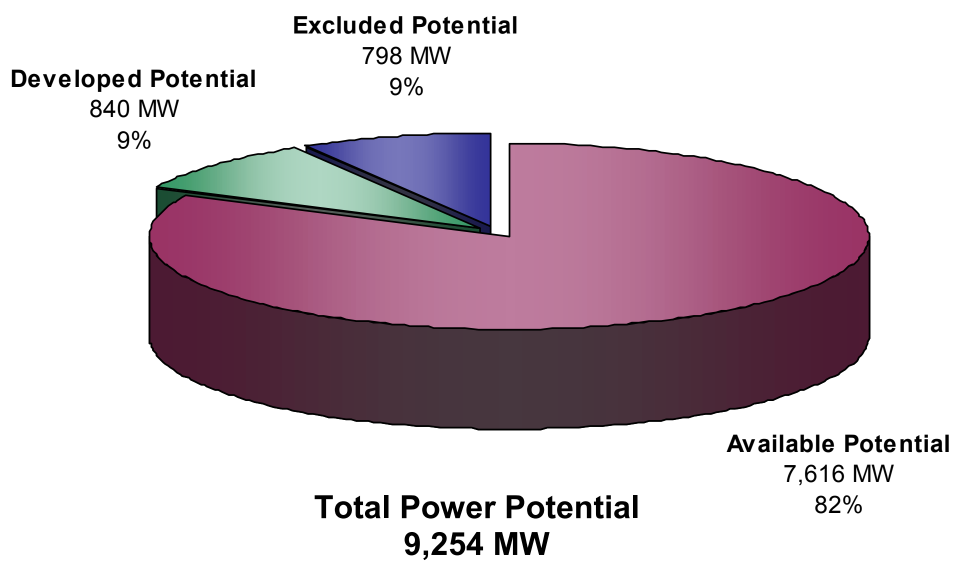

Figure A-7. Power category distribution of the total power potential (annual mean power) of water energy resources in the Middle Atlantic Region (HUC 2).

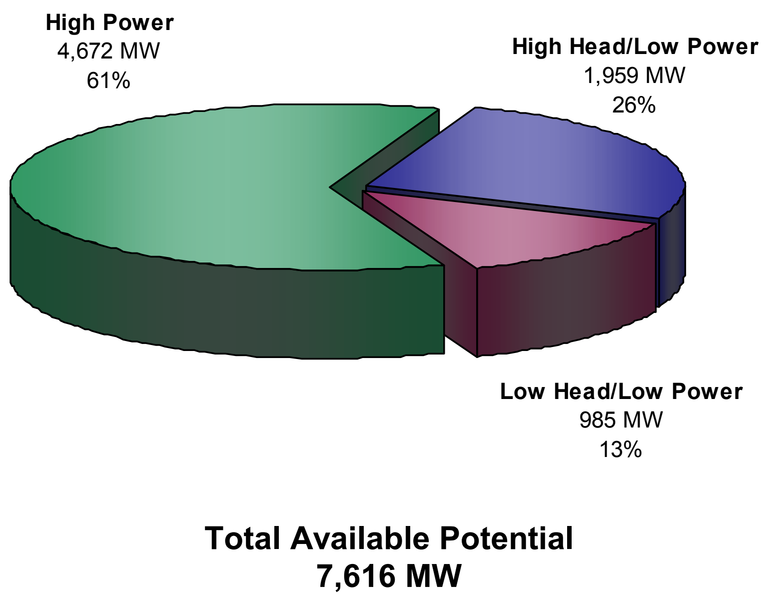

Figure A-8. Power class distribution of the available power potential (annual mean power) of water energy resources in the Middle Atlantic Region (HUC 2).

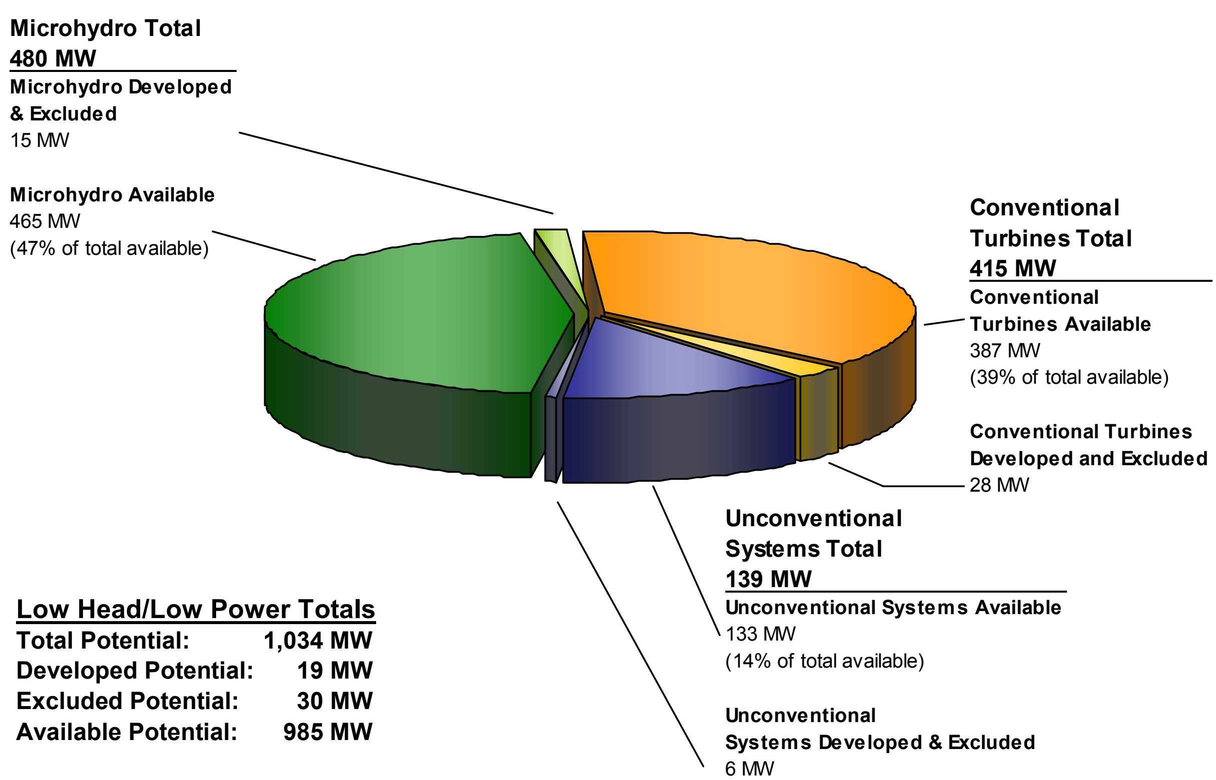

Figure A-9. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Middle Atlantic Region (HUC 2) among three low head/low power hydropower technology classes.

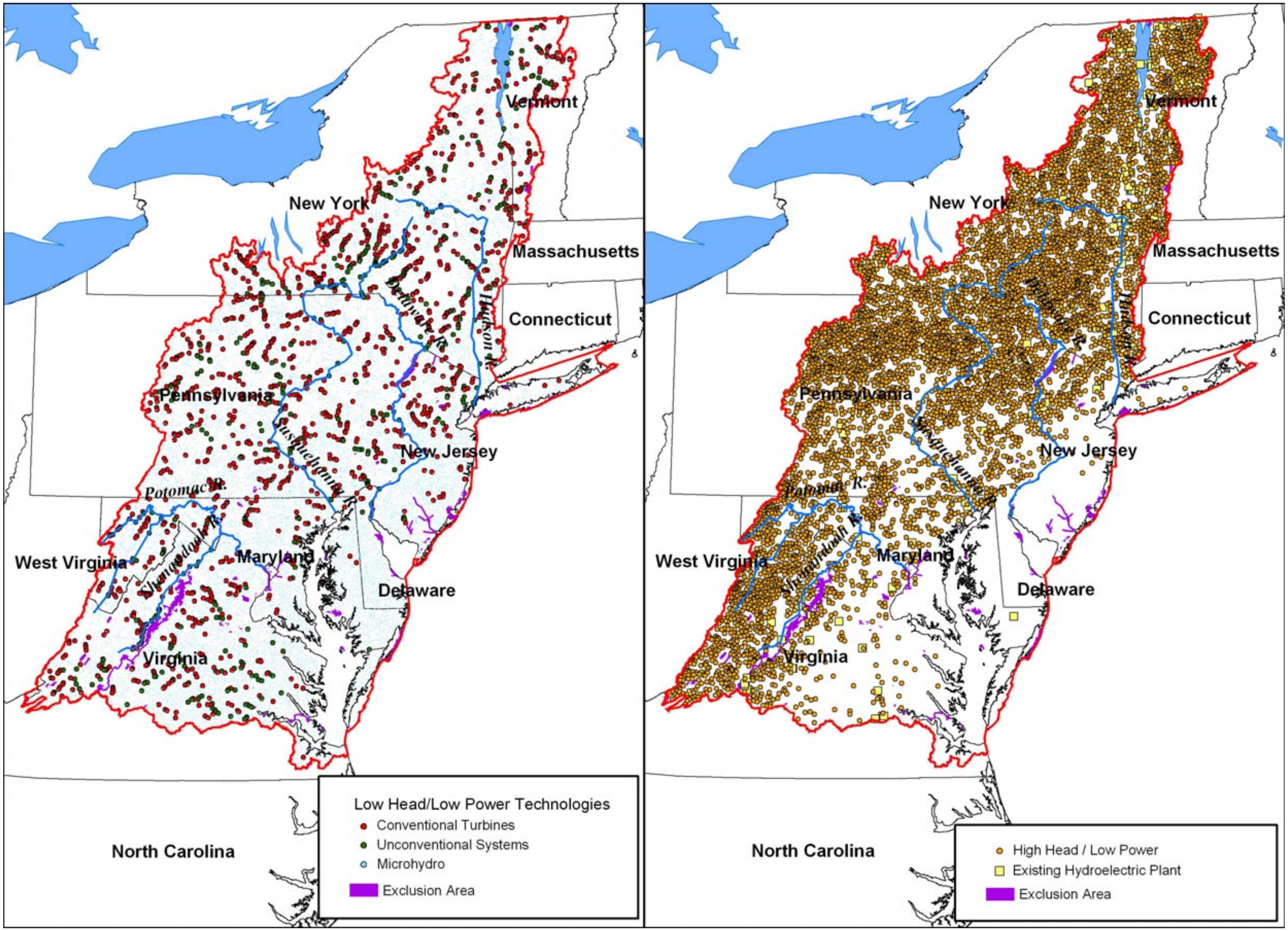

Figure A-10. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Middle Atlantic Region (HUC 2).

A.3 South Atlantic-Gulf Region

A.3.1 Region Description

The topographic and hydrographic features of the South Atlantic-Gulf Region are shown in Figure A-11. The region includes all watersheds from southern Virginia to Mississippi that drain to the Atlantic Ocean or the Gulf of Mexico. A broad, flat, extensive coastal plain underlies most of the region. The plain is composed of the Atlantic Coastal Plain and the Gulf Coastal Plain along the Atlantic and Gulf coasts, respectively. These plains extend beyond the water's edge to form a wide continental shelf, sometimes extending hundreds of miles offshore. In Virginia, North Carolina, Georgia, and Alabama, the plain transitions inland through a hilly upland area known as the Piedmont, with some river headwaters extending into the southern Appalachian Mountains. There are no mountains in other portions of the region, such as eastern Mississippi and southeastern Louisiana, South Carolina, and Florida.

The region contains several moderate-sized rivers including the Pee Dee, Savannah, St. Johns, Chattahoochee and Alabama Rivers. The rivers generally follow parallel courses from the highlands to the sea. Bays indent much of the coastline, and barrier islands separate many of the bays from the open water, especially in North Carolina and Florida. The folded rock layers of the southern Appalachians occupy the northern border of the region, while the main coastal plain is underlain by thick, mostly horizontal sedimentary layers. Limestone is found in much of the Florida peninsula; in many areas groundwater has dissolved the limestone to produce sinkholes. The flat topography and high rainfall has created areas of poor drainage such as the Okefenokee Swamp of southern Georgia and the Florida Everglades.

The climate in the South Atlantic-Gulf Region ranges from temperate in the north to subtropical in south Florida. Mountains and the northern part of the region can see winter snows, but the remainder of the region has mild winters and hot, humid summers. The entire region is subject to tropical storms and hurricanes.

A.3.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

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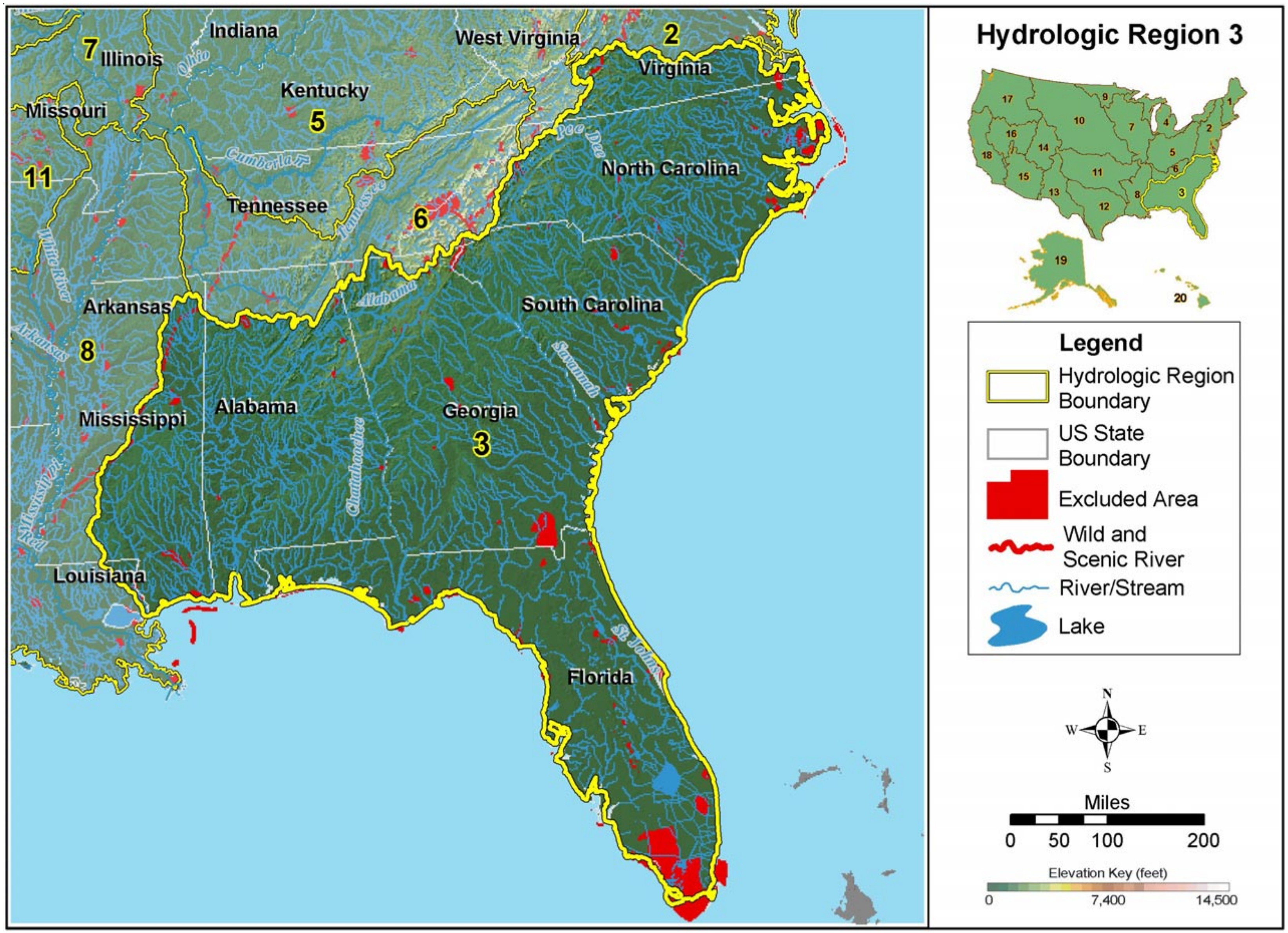


Figure A-11. South Atlantic-Gulf Region (HUC 3).

Table A-3. Summary of results of water energy resource assessment of the South Atlantic-Gulf Region (HUC 3).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**8,661**	**1,850**	**453**	**6,358**
TOTAL HIGH POWER	**5,560**	**1,824**	**370**	**3,366**
High Head/High Power	**2,930**	**1,795**	**259**	**876**
Low Head/High Power	**2,630**	**29**	**111**	**2,490**
TOTAL LOW POWER	**3,101**	**26**	**83**	**2,992**
High Head/Low Power	**781**	**12**	**31**	**738**
Low Head/Low Power	**2,320**	**14**	**52**	**2,254**
Conventional Turbine	773	13	17	743
Unconventional Systems	527	0	20	507
Microhydro	1,020	1	15	1,004

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

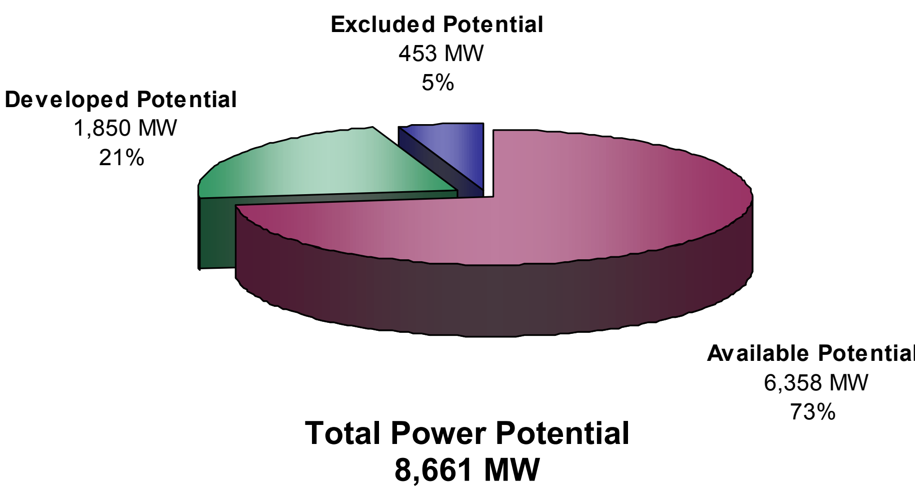


Figure A-12. Power category distribution of the total power potential (annual mean power) of water energy resources in the South Atlantic-Gulf Region (HUC 3).

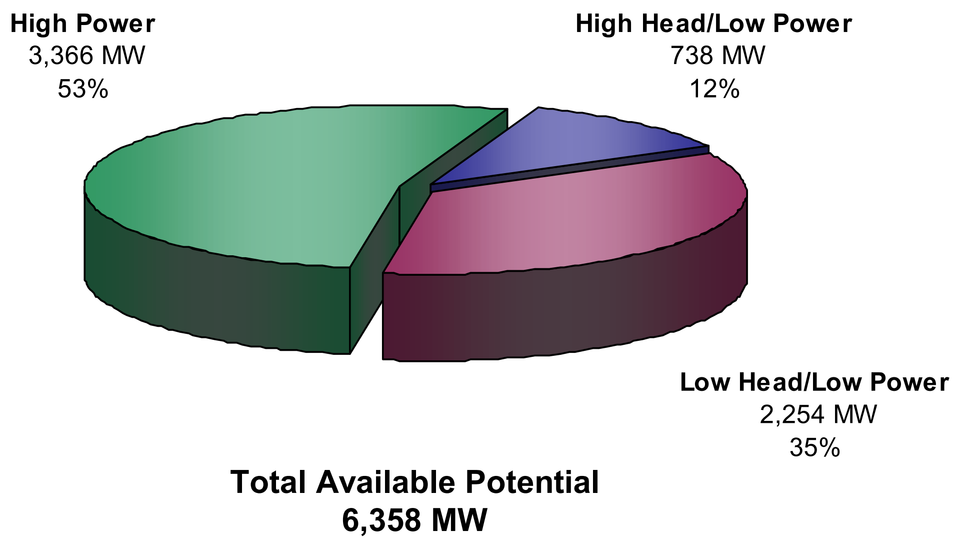


Figure A-13. Power class distribution of the available power potential (annual mean power) of water energy resources in the South Atlantic-Gulf Region (HUC 3).

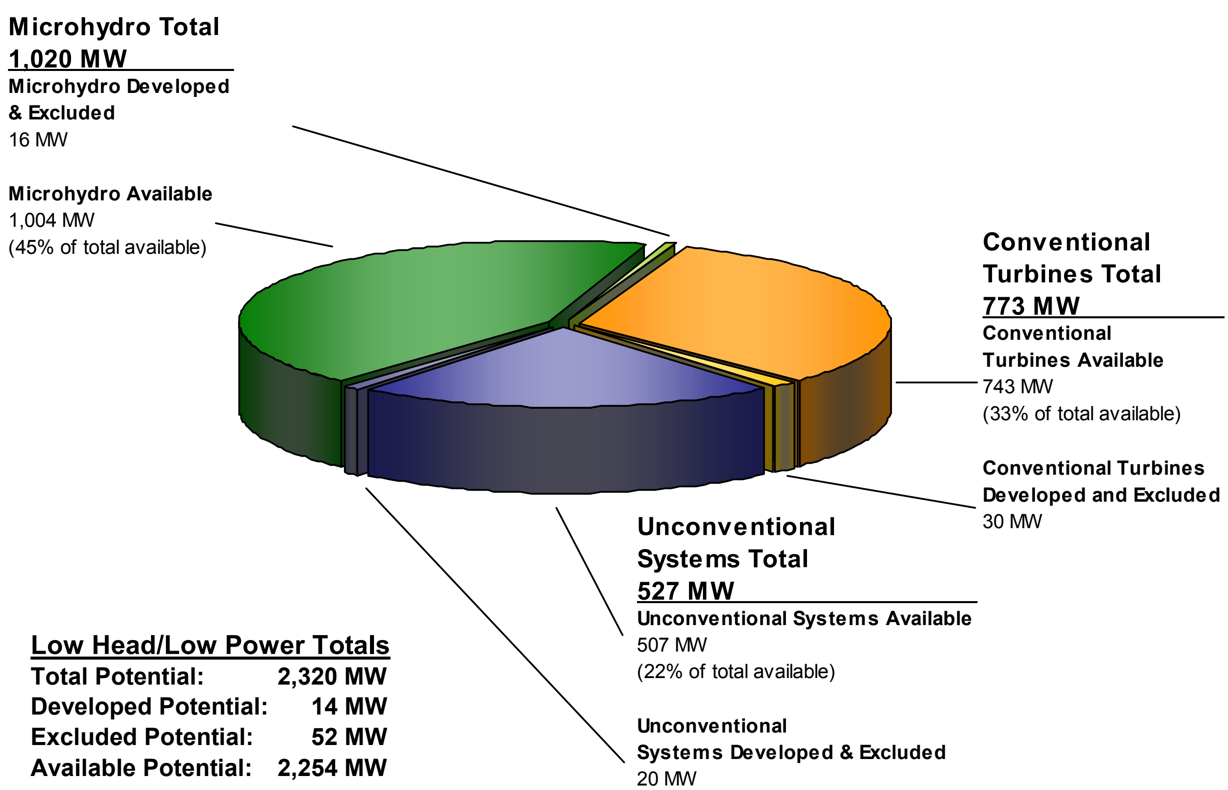


Figure A-14. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the South Atlantic-Gulf Region (HUC 3) among three low head/low power hydropower technology classes.

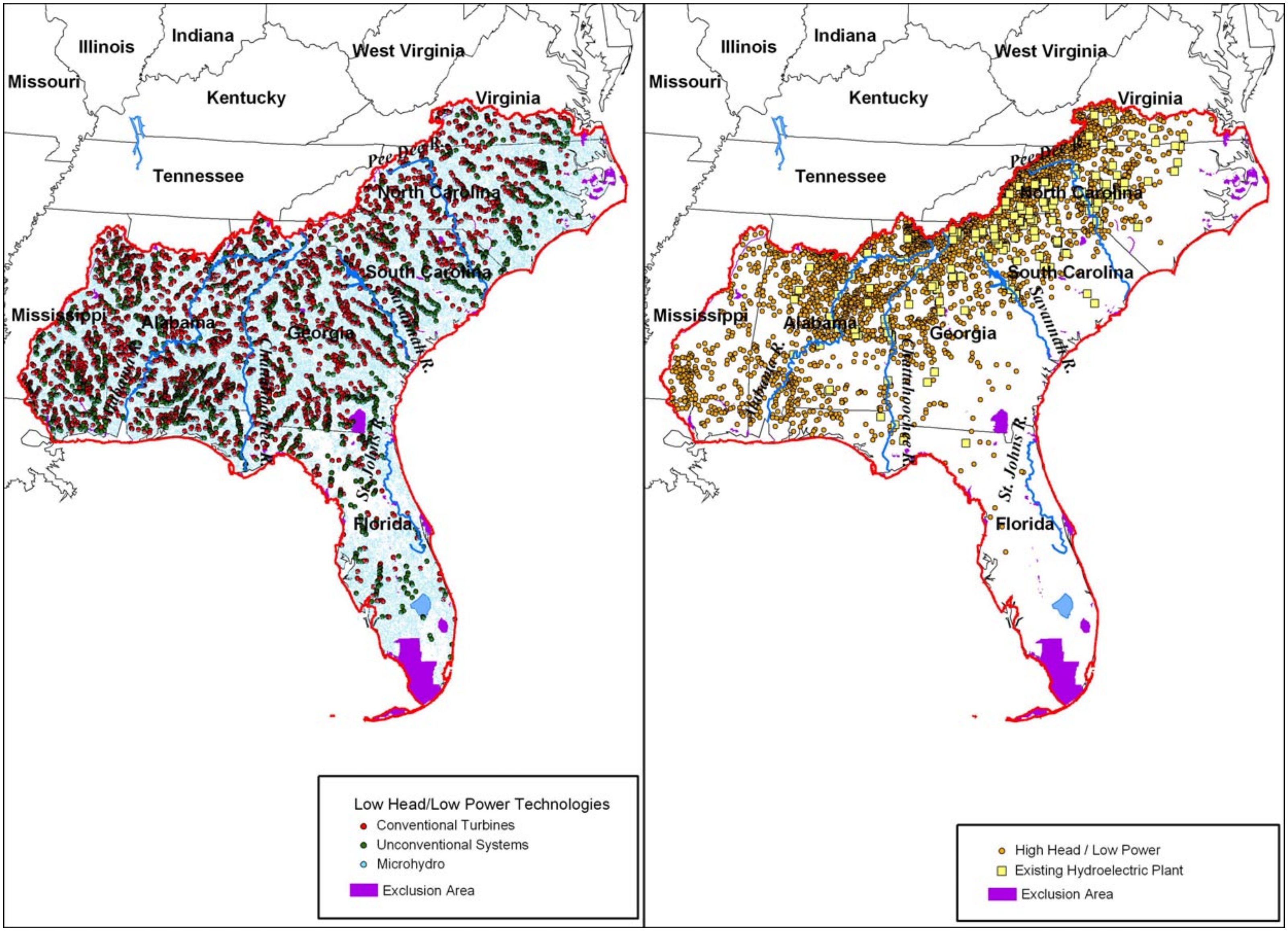


Figure A-15. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the South Atlantic-Gulf Region (HUC 3).

A.4 Great Lakes Region

A.4.1 Region Description

The topographic and hydrographic features of the Great Lakes Region are shown in Figure A-16. The region extends approximately 1,000 miles from east to west encompassing the watershed along the United States shoreline of the five Great Lakes as well as a portion of the St. Lawrence River watershed. The region includes nearly all of Michigan as well as parts of Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and western New York. In general, these watersheds do not extend far inland from the lakeshore, which is unusual considering the vast size of the lakes themselves. Near Chicago, Illinois, streams only a few miles from Lake Michigan flow to the Gulf of Mexico rather than the nearby lake.

The principal water bodies of the region are the Great Lakes: Lake Superior, Lake Huron, Lake Michigan, Lake Erie, and Lake Ontario. Principal rivers include rivers connecting the lakes, such as the Niagara and St. Clair Rivers, as well as the St. Lawrence River downstream from Lake Ontario. Canals connect the Great Lakes to the tributaries of the Mississippi and Hudson Rivers, enabling navigation from the lakes to the Atlantic Ocean and the Gulf of Mexico. Hydropower projects in the area often take advantage of the elevation differences between the lakes. For example, much of the Niagara River is diverted upstream of Niagara Falls for hydropower production.

The landscape is generally flat, with coniferous forests in the north and mixed farmland/deciduous woodland in the south. The region contains many ice age glacial remnants such as outwash deposits and moraines. The Great Lakes Region includes many urban and industrial centers including Chicago, Illinois; Detroit, Michigan; and Cleveland, Ohio. Climate in the region is continental, with cold winters (severe in the north) and warm to hot, humid summers.

A.4.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes

Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

For this hydrologic, the sum of developed and excluded power potentials exceeded the total power potential in the high head/high power power class resulting in a negative value in the available power potential category in this power class. This is thought to have occurred because the developed power is actually generated using resources in other power classes, e.g., where a reservoir overlays resources other than those in the high head/high power class.

In order to correct this anomaly, the amount of developed power in the high head/high power class exceeding the difference between the total high head/high power power potential and the sum of the developed and excluded power potentials in this power class was "rolled down" into lower power classes. The excess developed power was apportioned to the low power classes by the amount of developed power that was originally assigned to them. Data values affected by developed power redistribution are shown in yellow font on a green background.

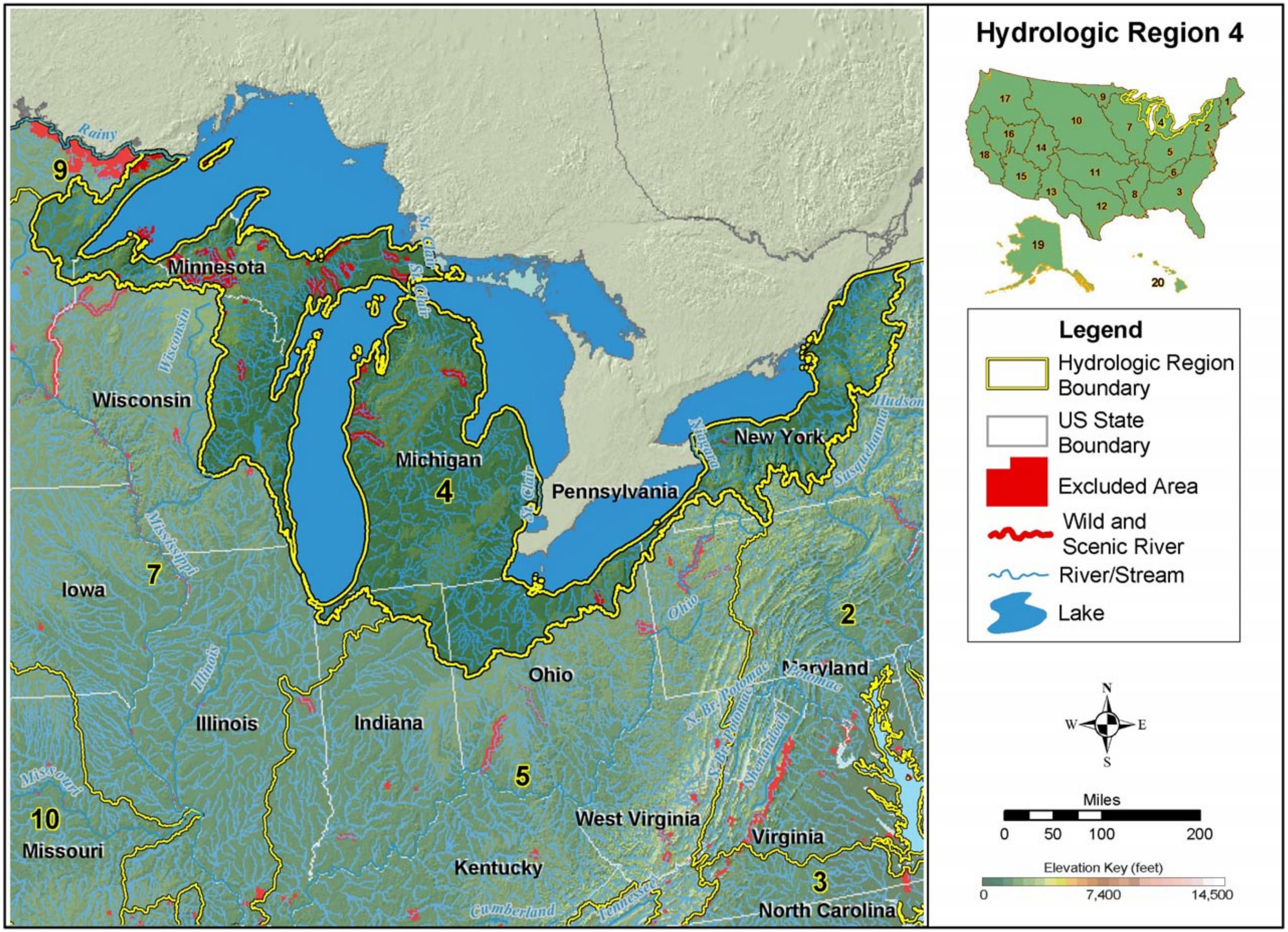


Figure A-16. Great Lakes Region (HUC 4).

Table A-4. Summary of results of water energy resource assessment of the Great Lakes Region (HUC 4).

Annual Mean Power (MW)	Total	Developed[a]	Excluded	Available[a,b]
TOTAL POWER	**4,353**	**2,852**	**271**	**1,230**
TOTAL HIGH POWER	**2,594**	**2,427**	**167**	**0**
High Head/High Power	**2,177**	**2,028**	**149**	**0**
Low Head/High Power	**417**	**399**	**18**	**0**
TOTAL LOW POWER	**1,759**	**425**	**104**	**1,230**
High Head/Low Power	**779**	**165**	**41**	**573**
Low Head/Low Power	**980**	**260**	**63**	**657**
Conventional Turbine	368	254	34	80
Unconventional Systems	143	0	11	132
Microhydro	469	7	18	444

a. Developed high head/high power potential exceeded total potential in this power class probably because the developed power is made up of resources in other power classes. "Excess" developed power in the high head/high power class (593 MW) was rolled downward into lower power classes in this table to the extent that each lower power class could accommodate additional developed power without creating a negative available potential. "Excess" developed power was redistributed proportionally based on the original distribution of developed power among the lower power classes.

b. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

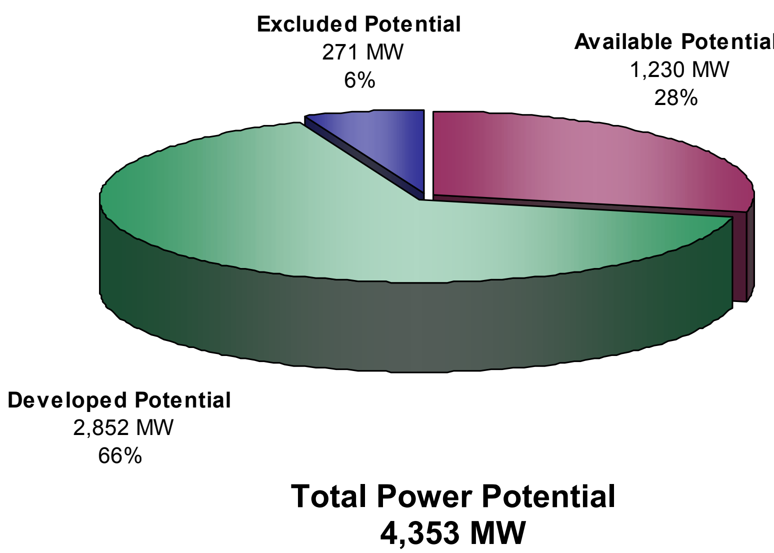


Figure A-17. Power category distribution of the total power potential (annual mean power) of water energy resources in the Great Lakes Region (HUC 4).

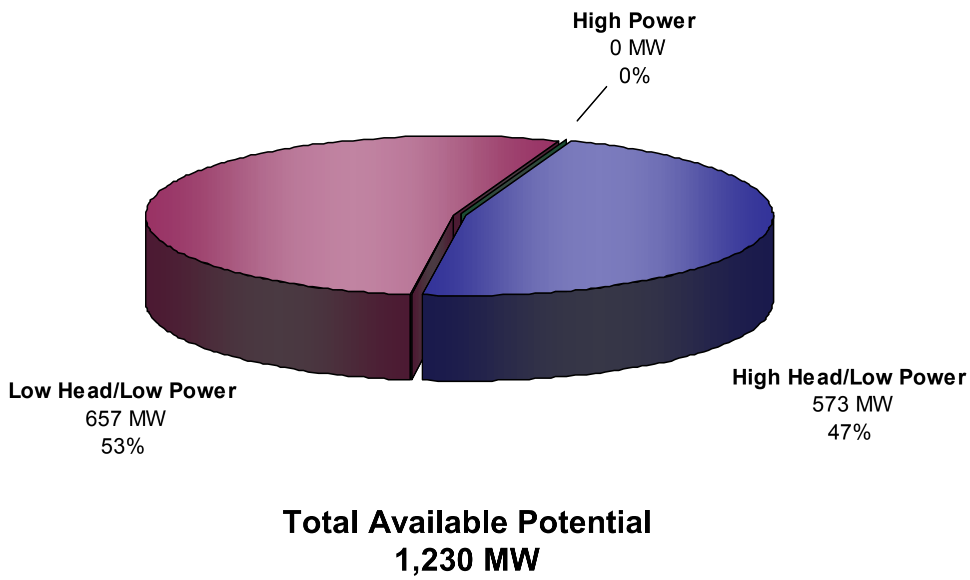


Figure A-18. Power class distribution of the available power potential (annual mean power) of water energy resources in the Great Lakes Region (HUC 4).

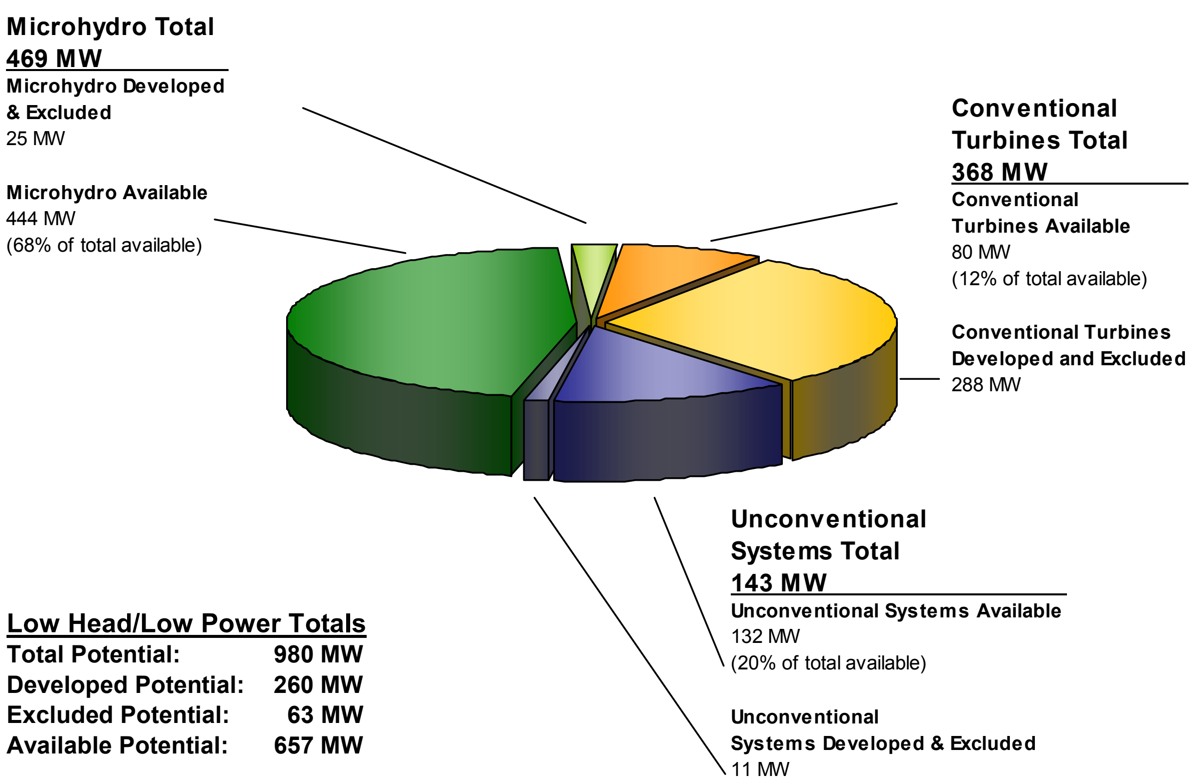


Figure A-19. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Great Lakes Region (HUC 4) among three low head/low power hydropower technology classes.

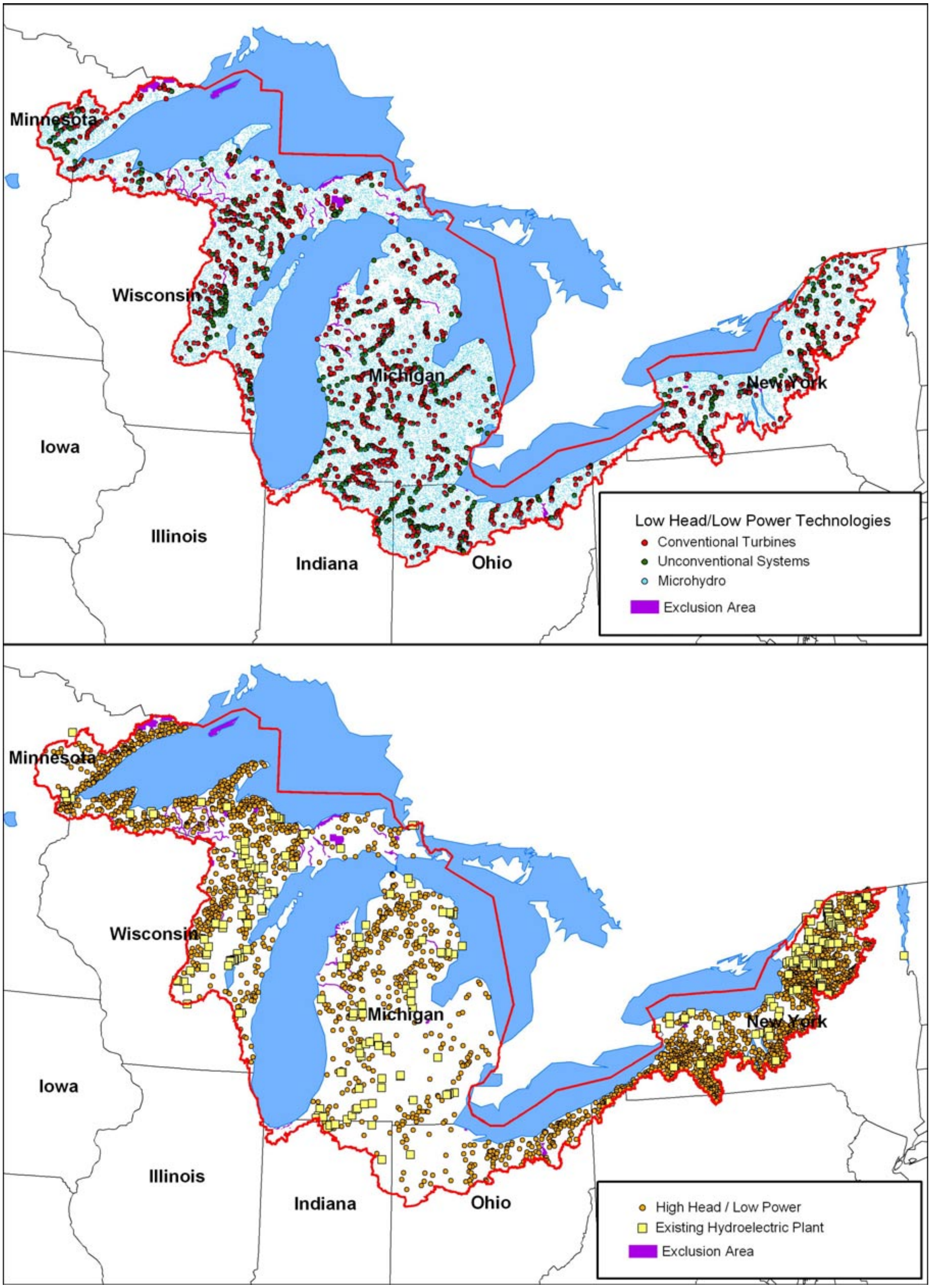


Figure A-20. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Great Lakes Region (HUC 4).

A.5 Ohio Region

A.5.1 Region Description

The topographic and hydrographic features of the Ohio Region are shown in Figure A-21. The region covers the entire Ohio River watershed, except for the Tennessee River watershed. It extends from the thickly wooded Appalachian Mountains in the north through mixed farmland/deciduous woodland of the Ohio Valley to the Mississippi River. The region encompasses most of Ohio, Indiana, Kentucky, and West Virginia as well as portions of Illinois, Tennessee, Virginia, Maryland, Pennsylvania, and New York. The Ohio River is navigable for much of its length, serving as an inland waterway that links the Gulf of Mexico to the Great Lakes and the Atlantic Ocean. The climate is temperate to continental, with influences from both cold Canadian air masses and warm Gulf air masses. Winters can be cold, summers warm, and springs and autumns pleasant.

A.5.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

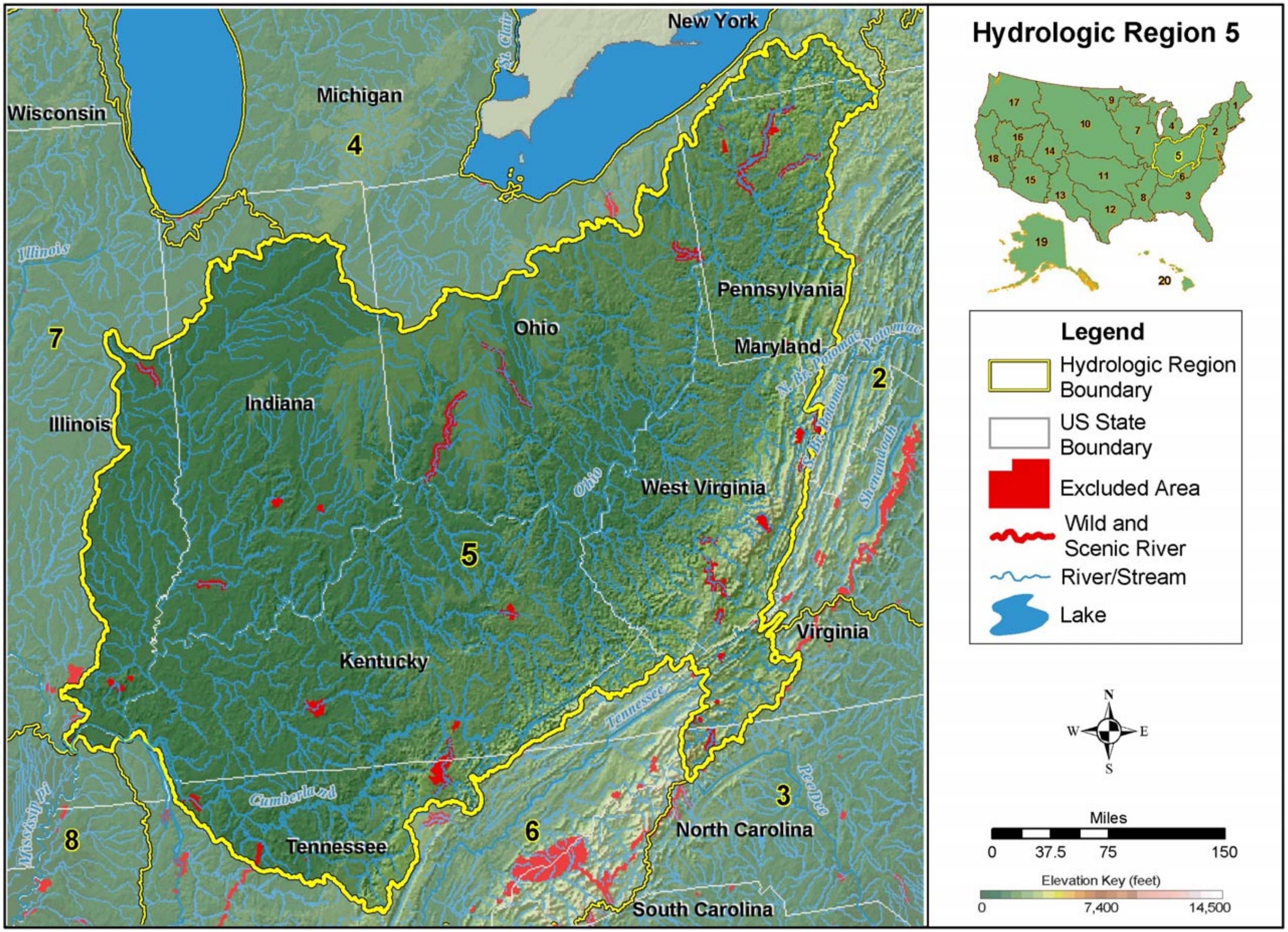


Figure A-21. Ohio Region (HUC 5).

Table A-5. Summary of results of water energy resource assessment of the Ohio Region (HUC 5).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**12,109**	**820**	**1,275**	**10,014**
TOTAL HIGH POWER	**9,212**	**816**	**1,144**	**7,252**
High Head/High Power	**4,120**	**674**	**807**	**2,639**
Low Head/High Power	**5,092**	**142**	**337**	**4,613**
TOTAL LOW POWER	**2,897**	**4**	**131**	**2,762**
High Head/Low Power	**1,298**	**1**	**78**	**1,219**
Low Head/Low Power	**1,599**	**3**	**53**	**1,543**
Conventional Turbine	592	3	24	565
Unconventional Systems	218	0	10	208
Microhydro	789	0	19	770

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

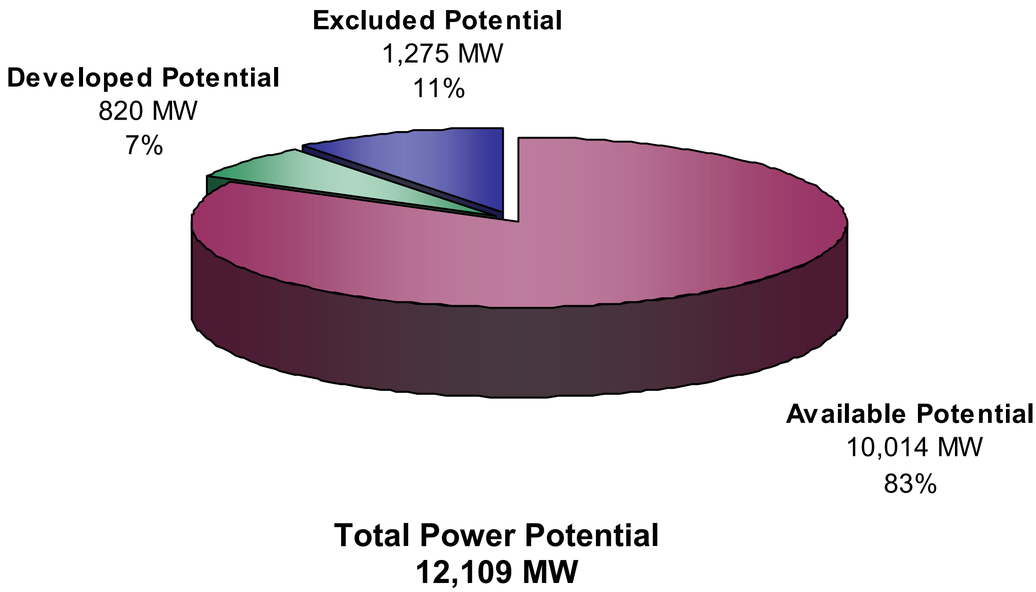


Figure A-22. Power category distribution of the total power potential (annual mean power) of water energy resources in the Ohio Region (HUC 5).

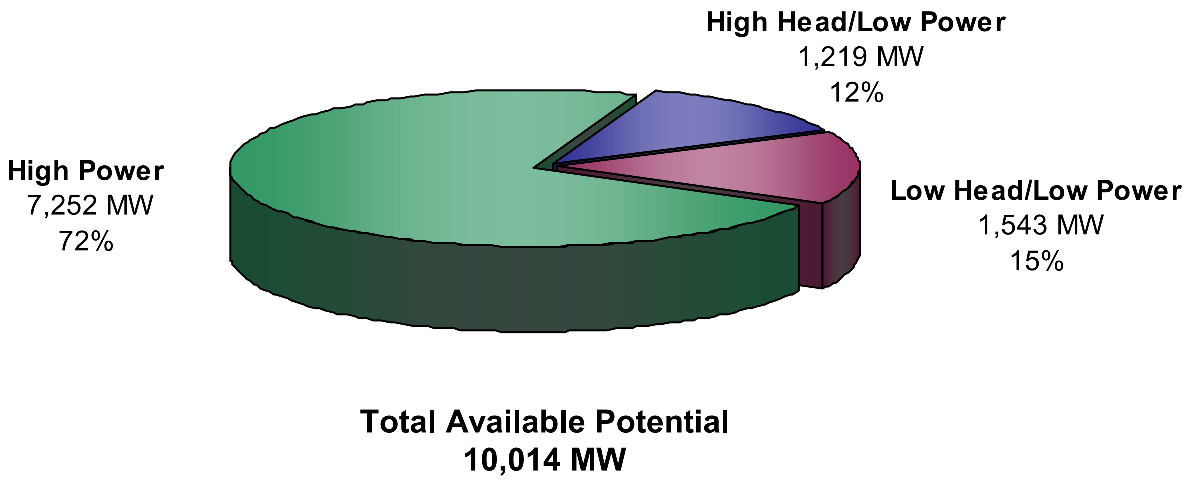


Figure A-23. Power class distribution of the available power potential (annual mean power) of water energy resources in the Ohio Region (HUC 5).

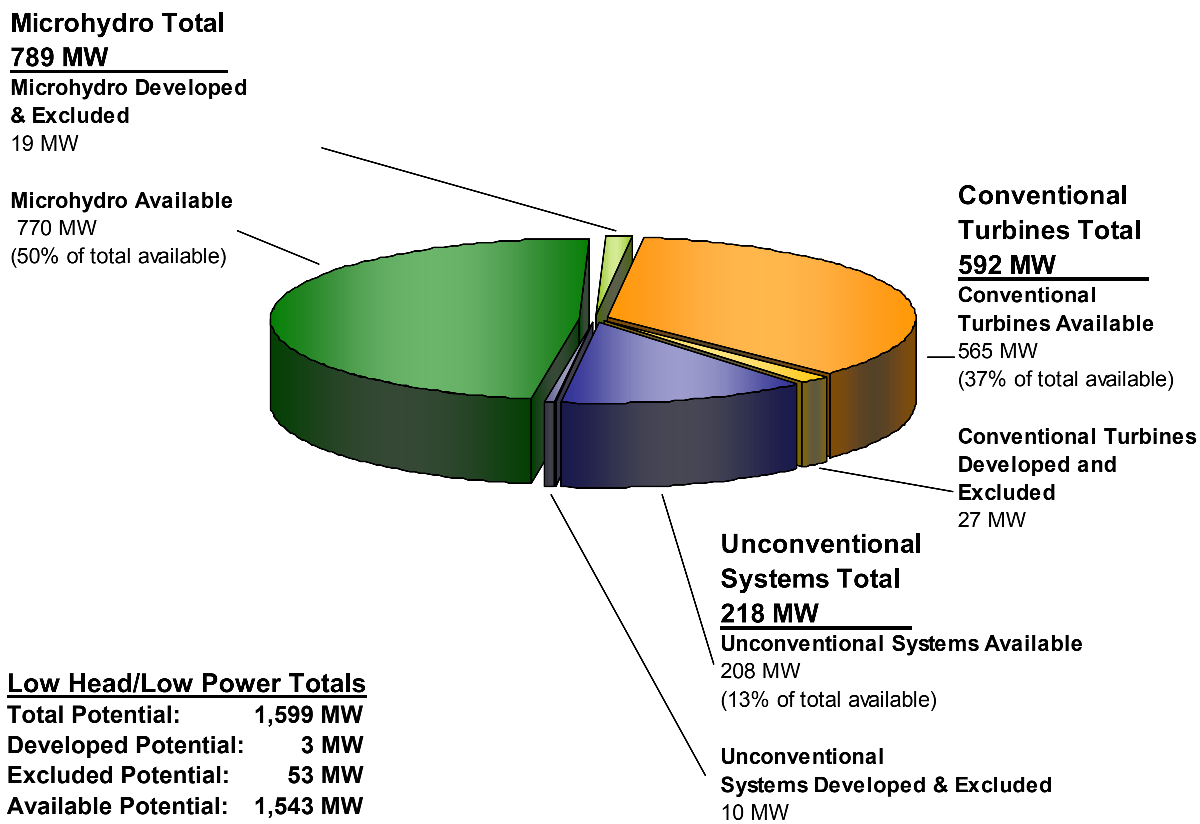


Figure A-24. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Ohio Region (HUC 5) among three low head/low power hydropower technology classes.

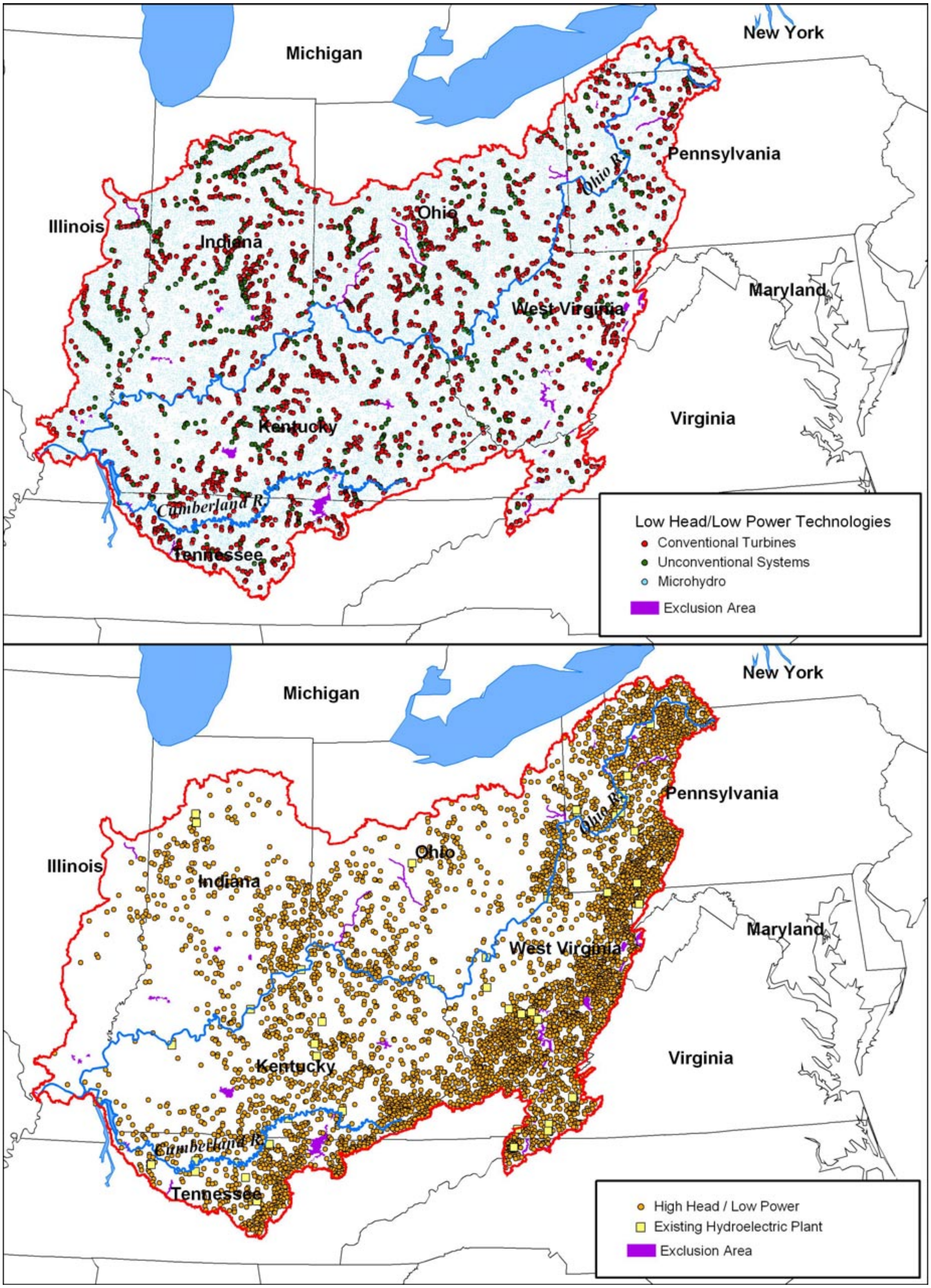


Figure A-25. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Ohio Region (HUC 5).

A.6 Tennessee Region

A.6.1 Region Description

The topographic and hydrographic features of the Tennessee Region are shown in Figure A-26. The region encompasses the Tennessee River watershed and covers much of Tennessee as well as parts of Kentucky, Mississippi, Alabama, Georgia, North Carolina and Virginia. The eastern end of the region includes the headwaters of the Cumberland River in the Cumberland Plateau of the Appalachian Mountains. Rolling hills, deciduous woodland, grassland and river valleys dominate the remainder of the region. The climate is temperate, with ample precipitation.

Although small in area compared to other hydrologic regions, the Tennessee Region contains many of the nation's largest and best-known hydropower projects. The Tennessee Valley Authority, a federal agency created in the 1930s, constructed a series of dams, reservoirs, and power plants along the Tennessee, Cumberland, and other rivers in the region. They provide water storage, flood control, recreation, and hydropower to parts of the southeastern United States. For its size, the Tennessee Region has the highest concentration of hydropower development than any other region in the United States except the Pacific Northwest Region (HUC 17).

A.6.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

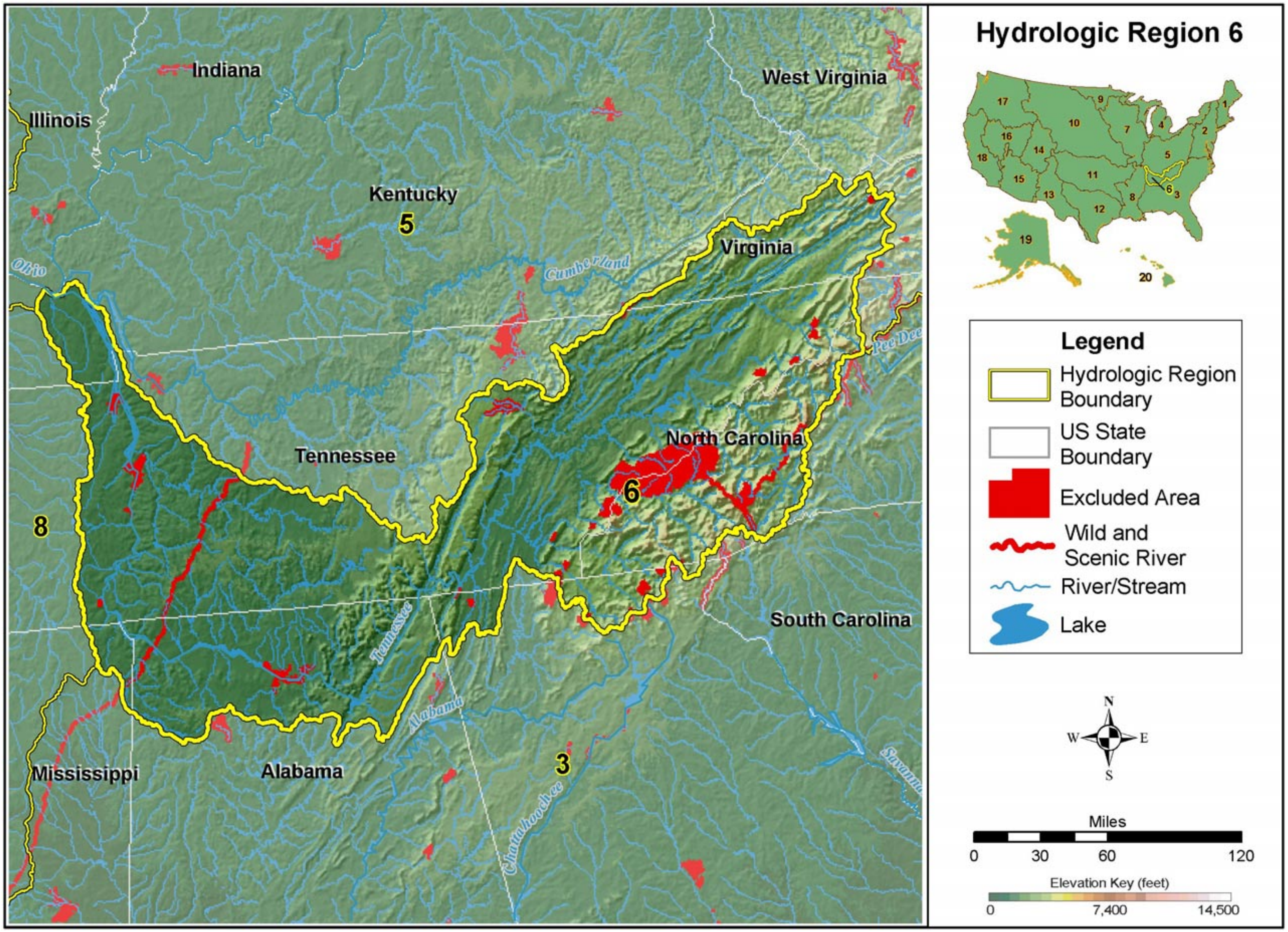


Figure A-26. Tennessee Region (HUC 6).

Table A-6. Summary of results of water energy resource assessment of the Tennessee Region (HUC 6).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**5,075**	**1,859**	**743**	**2,473**
TOTAL HIGH POWER	**3,871**	**1,855**	**582**	**1,434**
High Head/High Power	**3,011**	**1,851**	**542**	**618**
Low Head/High Power	**860**	**4**	**40**	**816**
TOTAL LOW POWER	**1,204**	**4**	**161**	**1,039**
High Head/Low Power	**782**	**3**	**141**	**638**
Low Head/Low Power	**422**	**1**	**20**	**401**
Conventional Turbine	151	1	7	143
Unconventional Systems	67	0	3	64
Microhydro	204	0	10	194

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

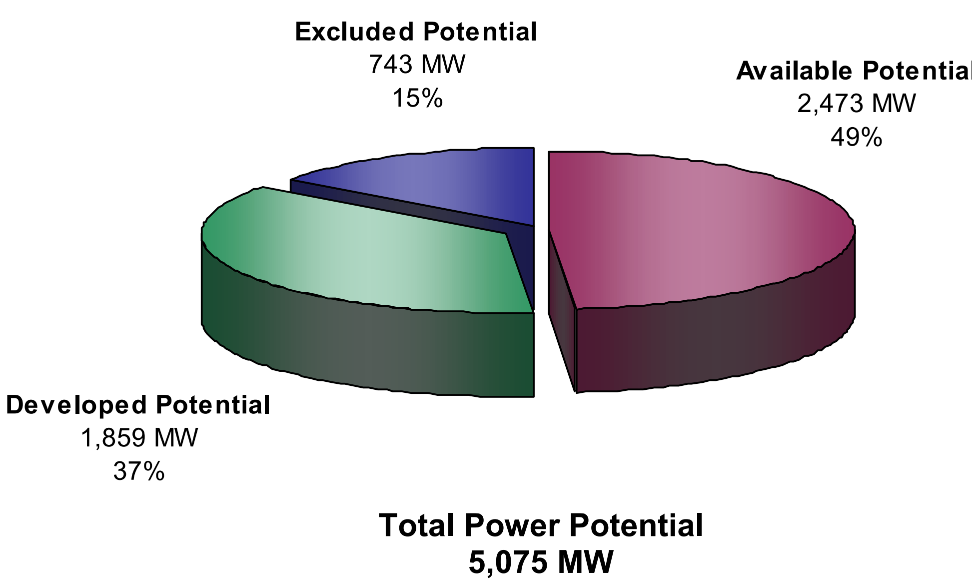


Figure A-27. Power category distribution of the total power potential (annual mean power) of water energy resources in the Tennessee Region (HUC 6).

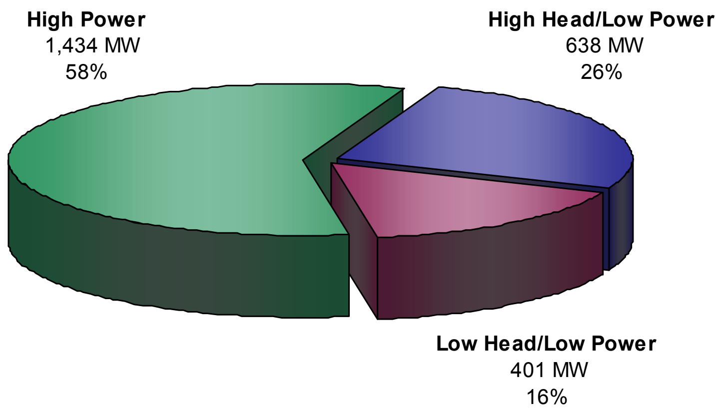


Figure A-28. Power class distribution of the available power potential (annual mean power) of water energy resources in the Tennessee Region (HUC 6).

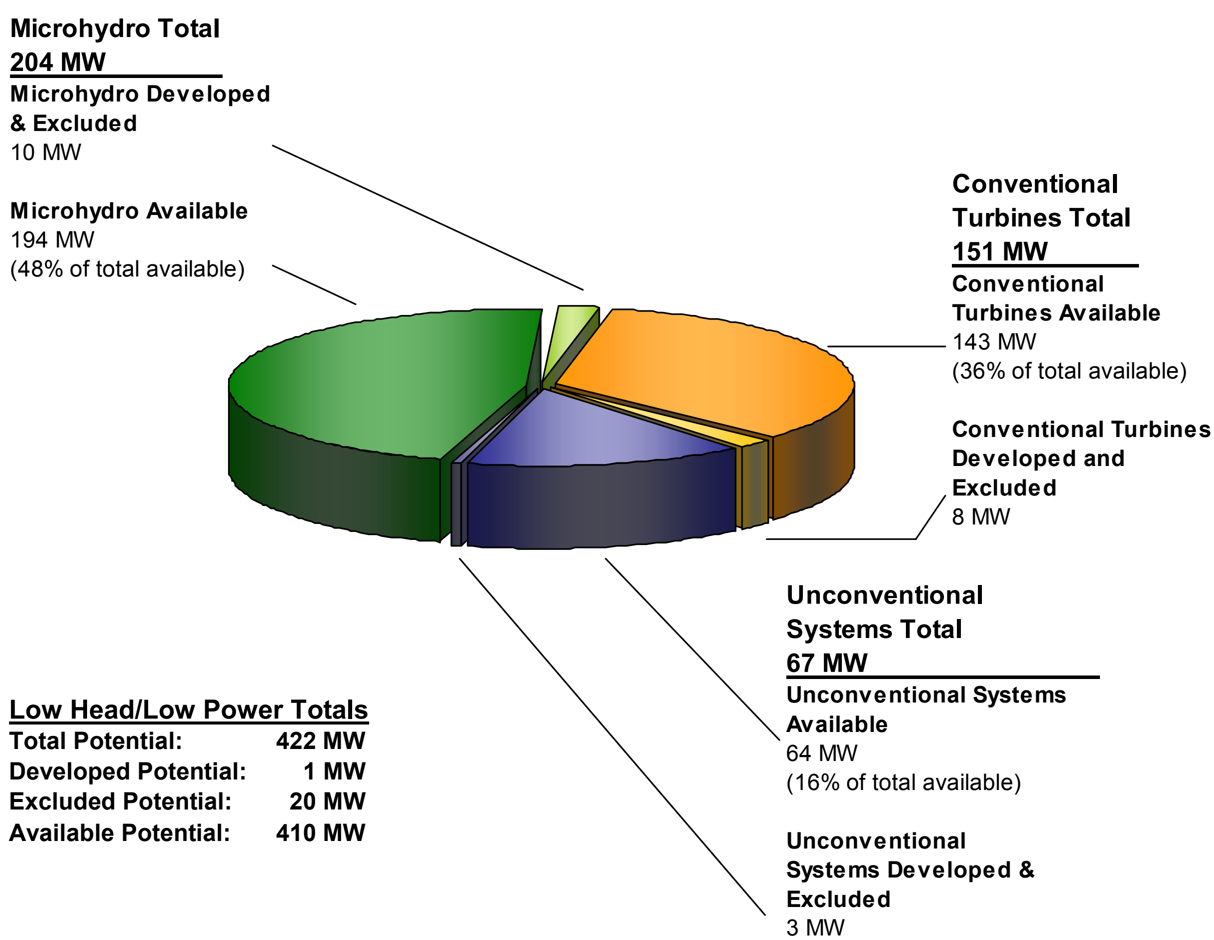


Figure A-29. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Tennessee Region (HUC 6) among three low head/low power hydropower technology classes.

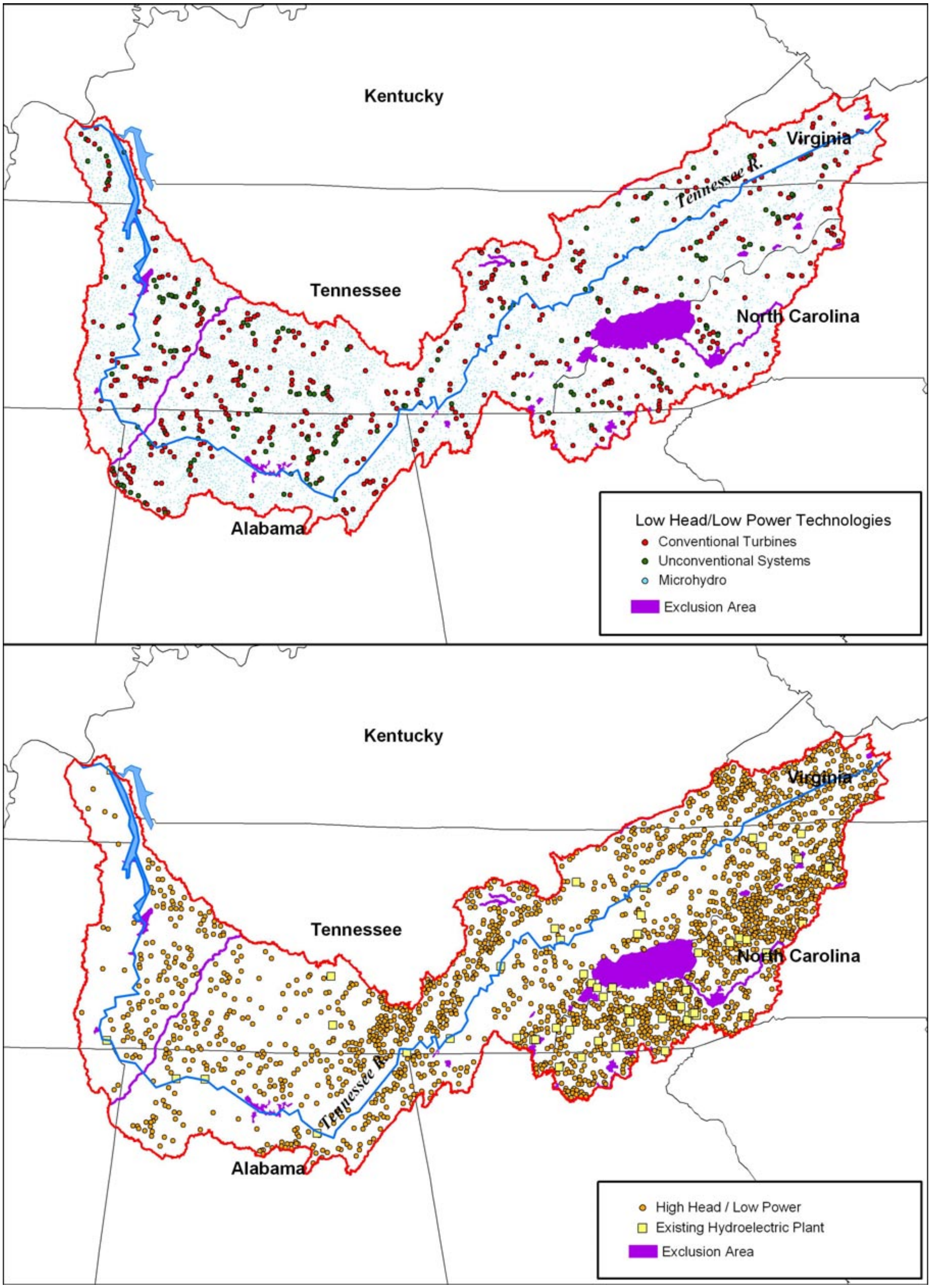


Figure A-30. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Tennessee Region (HUC 6).

A.7 Upper Mississippi Region

A.7.1 Region Description

The topographic and hydrographic features of the Upper Mississippi Region are shown in Figure A-31. The region consists of the Mississippi River watershed upstream of the Ohio River, excluding the Missouri River drainage. The region covers much of Illinois, Iowa, Minnesota, and Wisconsin, plus parts of Missouri, South Dakota, and Indiana. This area lies in the agricultural heartland of the United States.

The landscape consists primarily of rolling prairie with deep rich soils in many places. Glacial outwash and wind deposits underlie much of the region. The principal tributaries of the Mississippi in this area are the Illinois and Wisconsin Rivers. The Mississippi River is navigable upstream to Minneapolis/St. Paul, Minnesota. Topographic relief is minor, with elevations generally less than 1,500 feet. However, bluffs of 300 to 400 feet line the Mississippi River floodplain in some places. In many places, man-made channels and levees line the banks of the Mississippi River. They serve to create a stable channel suitable for navigation and provide flood control for nearby lowlands. These levees have successfully contained the normal floods from inundating towns and farmland in the surrounding floodplain. However, sediment buildup in the river channel has required the levee heights to be raised, which raises the overall level of the river. In many places, the river surface is higher than the surrounding floodplain.

A.7.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

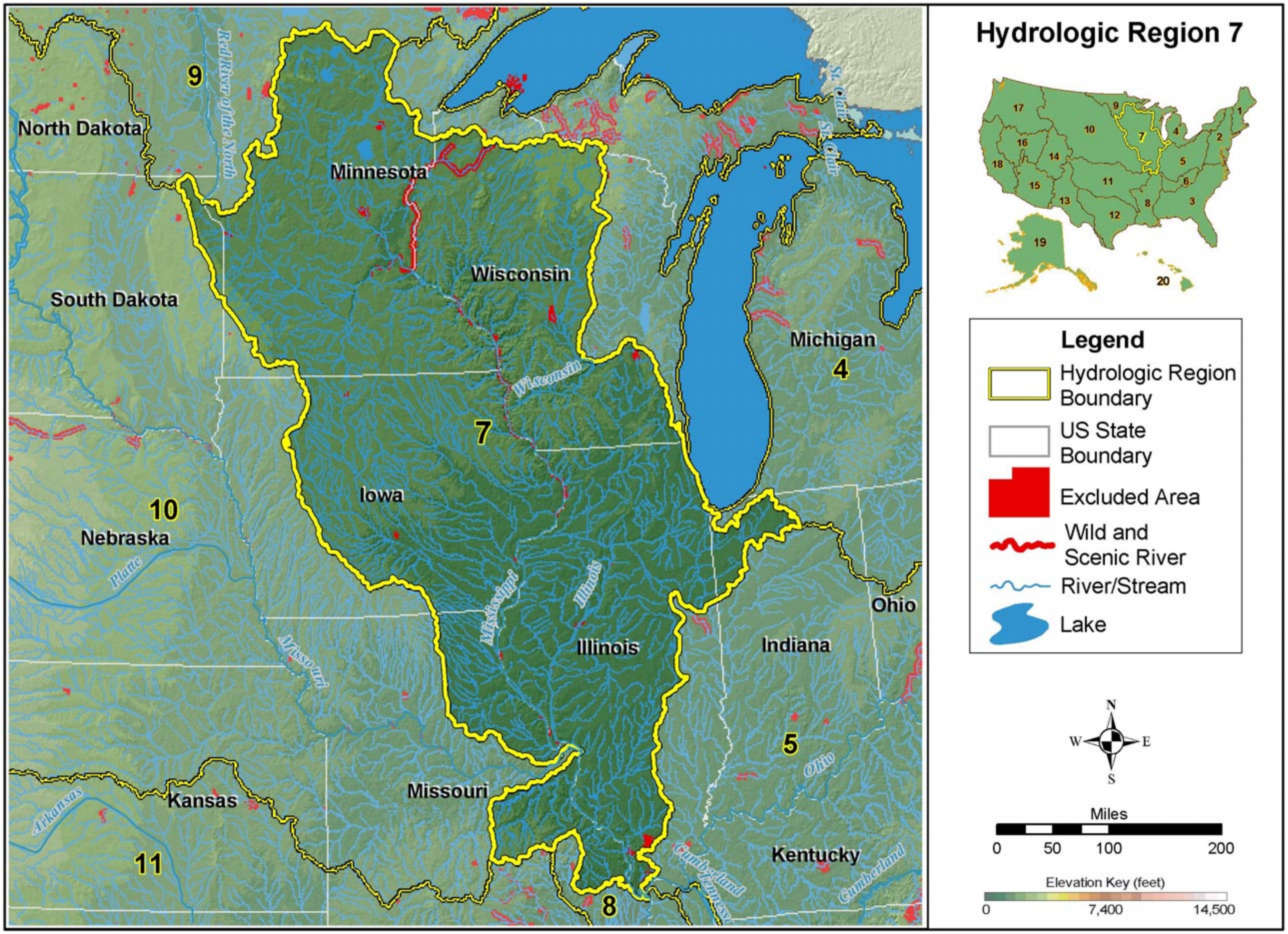


Figure A-31. Upper Mississippi Region (HUC 7).

Table A-7. Summary of results of water energy resource assessment of the Upper Mississippi Region (HUC 7).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**5,766**	**404**	**630**	**4,732**
TOTAL HIGH POWER	**4,092**	**386**	**571**	**3,135**
High Head/High Power	**462**	**294**	**65**	**103**
Low Head/High Power	**3,630**	**92**	**506**	**3,032**
TOTAL LOW POWER	**1,674**	**18**	**59**	**1,597**
High Head/Low Power	**240**	**5**	**11**	**224**
Low Head/Low Power	**1,434**	**13**	**48**	**1,373**
Conventional Turbine	484	12	14	458
Unconventional Systems	316	0	23	293
Microhydro	634	1	11	622

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

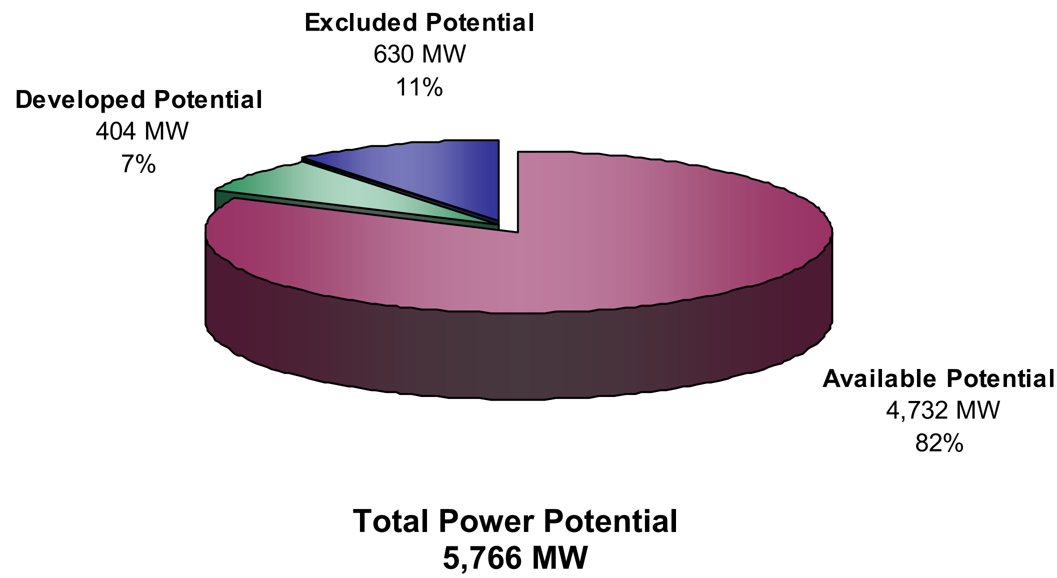


Figure A-32. Power category distribution of the total power potential (annual mean power) of water energy resources in the Upper Mississippi Region (HUC 7).

Upper Mississippi (HUC 7)

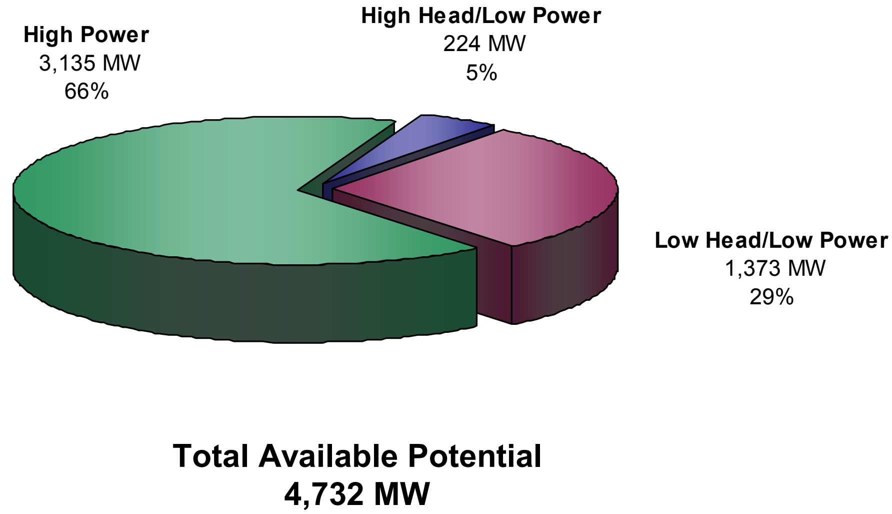


Figure A-33. Power class distribution of the available power potential (annual mean power) of water energy resources in the Upper Mississippi Region (HUC 7).

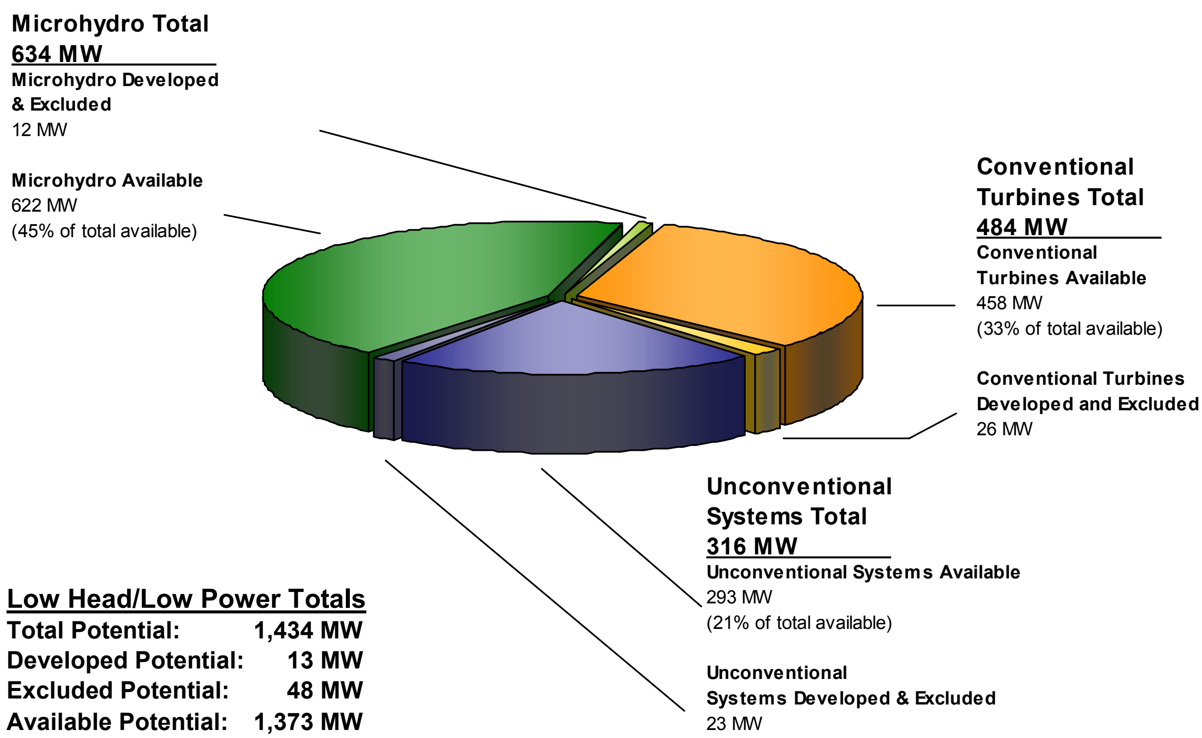


Figure A-34. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Upper Mississippi Region (HUC 7) among three low head/low power hydropower technology classes.

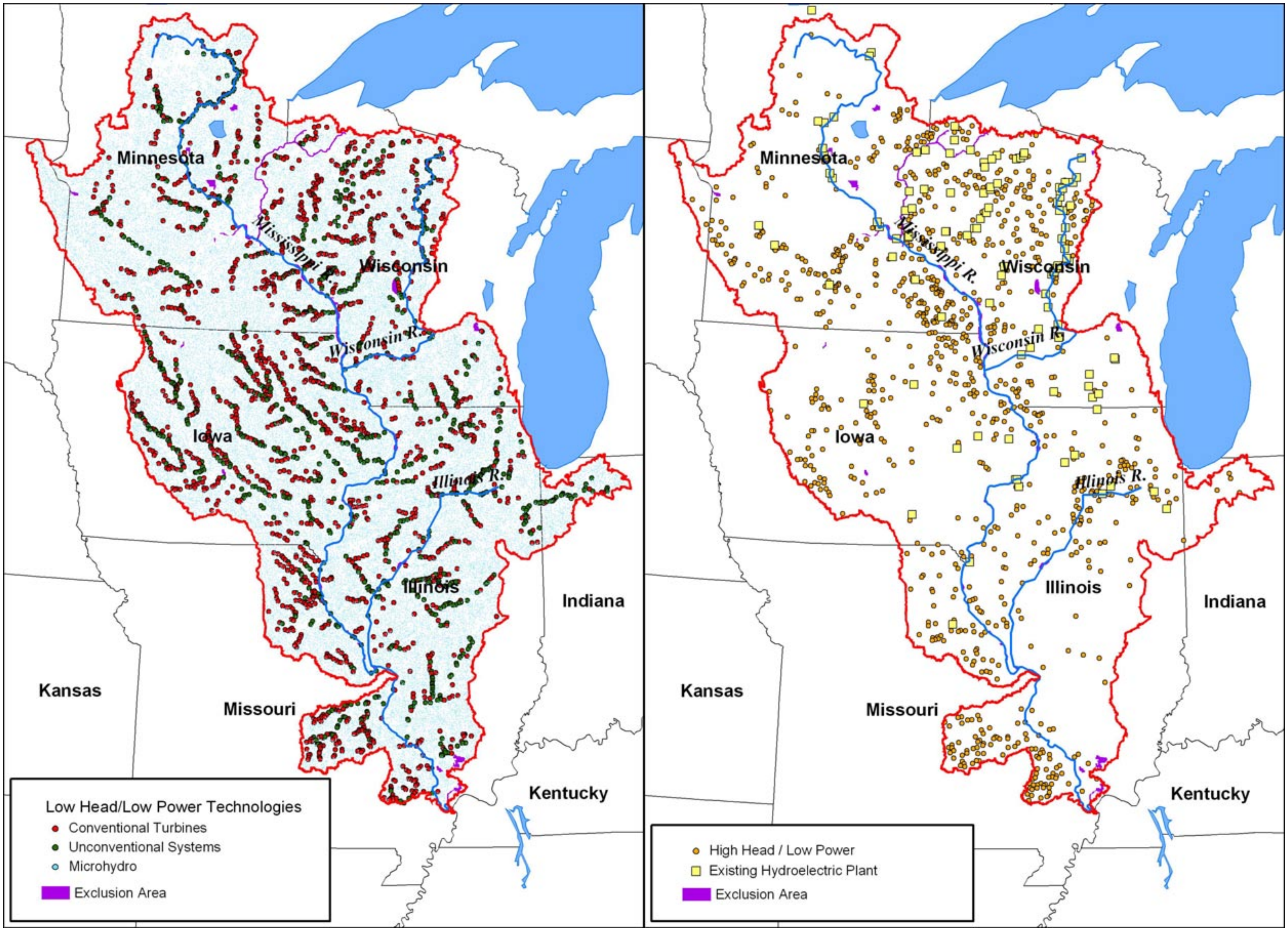


Figure A-35. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Upper Mississippi Region (HUC 7).

A.8 Lower Mississippi Region

A.8.1 Region Description

The topographic and hydrographic features of the Lower Mississippi Region are shown in Figure A-36. The region covers the Mississippi River downstream of its confluence with the Ohio River and the nearby watersheds. The region covers half of Mississippi and Arkansas, most of Louisiana, and parts of Kentucky, Tennessee, and Missouri that border the Mississippi River.

The region is dominated by the Mississippi River, its principal watercourse. The river is very large here, as it now carries the combined flows of the Ohio, upper Mississippi, Missouri, and numerous other rivers. The river meanders in a broad mature floodplain. In its natural state, the river channel periodically shifted within this floodplain. Oxbow lakes and marshes are the remnants of the abandoned river channels. In southern Louisiana, the river branches into several waterways to form the Mississippi River delta, where sediment loads from the river are deposited into the Gulf of Mexico. Like the upper Mississippi River, the lower reaches of the river contain channels and levees to permit navigation and prevent flooding of nearby lowlands.

Hills, plains, tributary river valleys, and pine woods occupy the uplands away from the main river floodplain. Wetlands composed of swamps and bayous dominate the delta areas of southern Louisiana and Mississippi. The climate in most of the region is warm and humid, with mild winters, abundant rainfall, and long growing seasons. Gulf coastal areas in particular are subject to tropical storms and hurricanes.

A.8.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

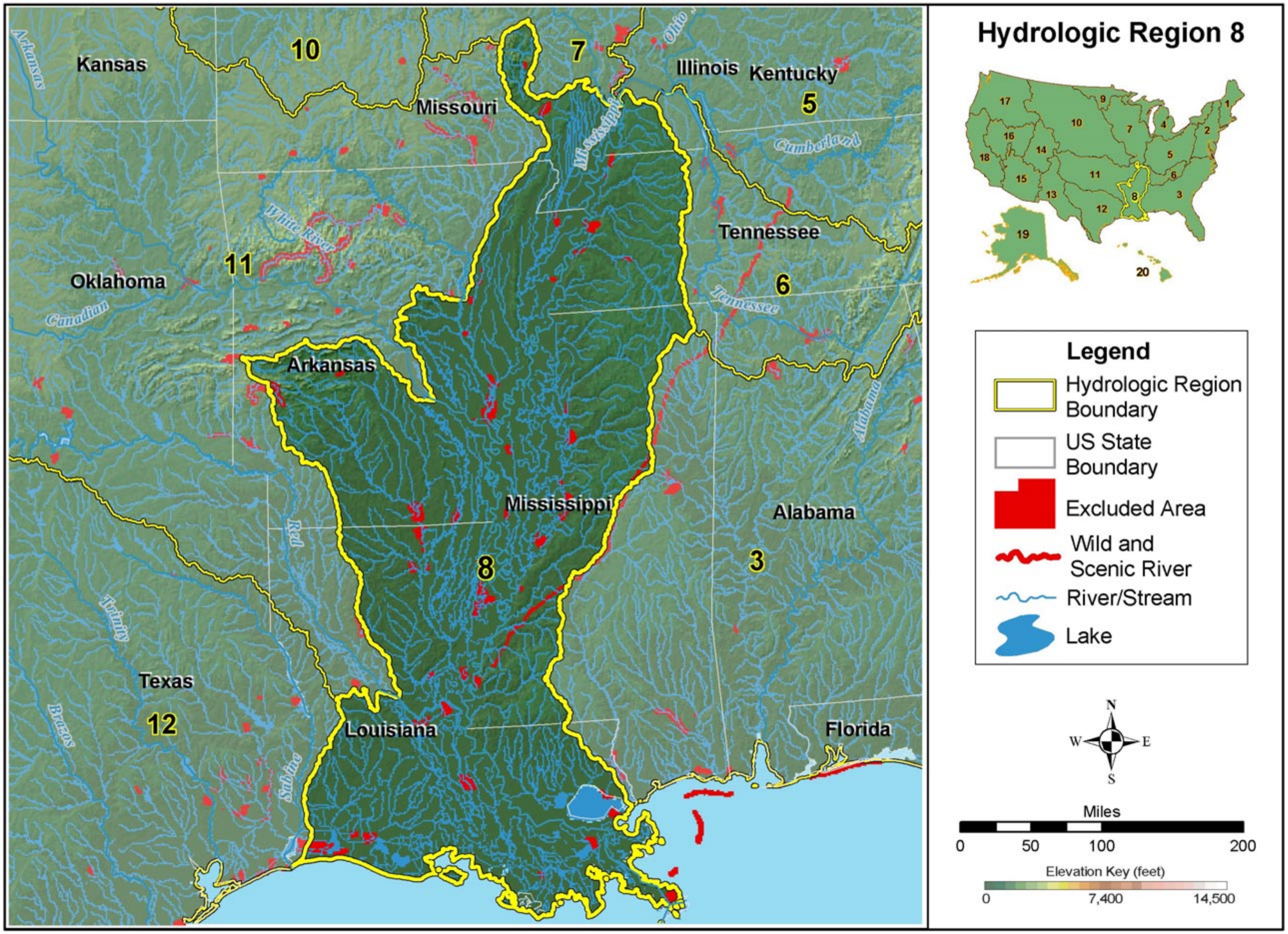


Figure A-36. Lower Mississippi Region (HUC 8).

Table A-8. Summary of results of water energy resource assessment of the Lower Mississippi Region (HUC 8).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**12,418**	**136**	**835**	**11,447**
TOTAL HIGH POWER	**11,553**	**136**	**805**	**10,612**
High Head/High Power	**170**	**47**	**0**	**123**
Low Head/High Power	**11,383**	**89**	**805**	**10,489**
TOTAL LOW POWER	**865**	**0**	**30**	**835**
High Head/Low Power	**104**	**0**	**7**	**97**
Low Head/Low Power	**761**	**0**	**23**	**738**
Conventional Turbine	215	0	6	209
Unconventional Systems	222	0	9	213
Microhydro	324	0	8	316

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

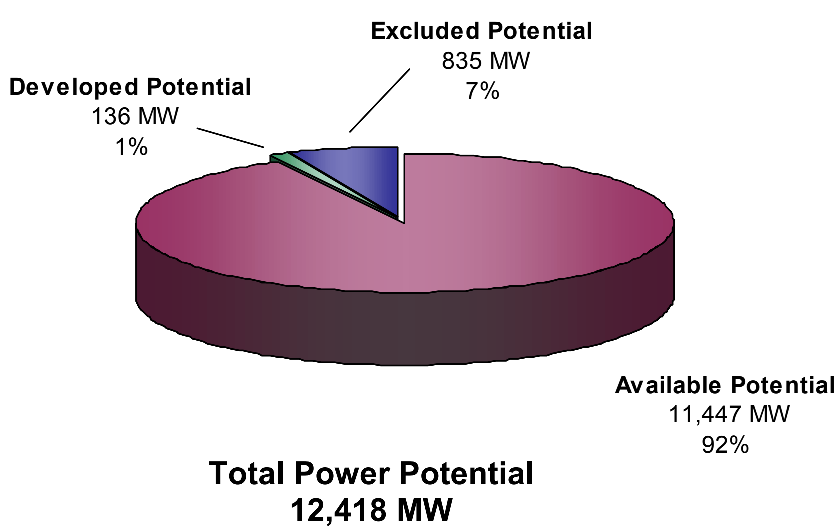


Figure A-37. Power category distribution of the total power potential (annual mean power) of water energy resources in the Lower Mississippi Region (HUC 8).

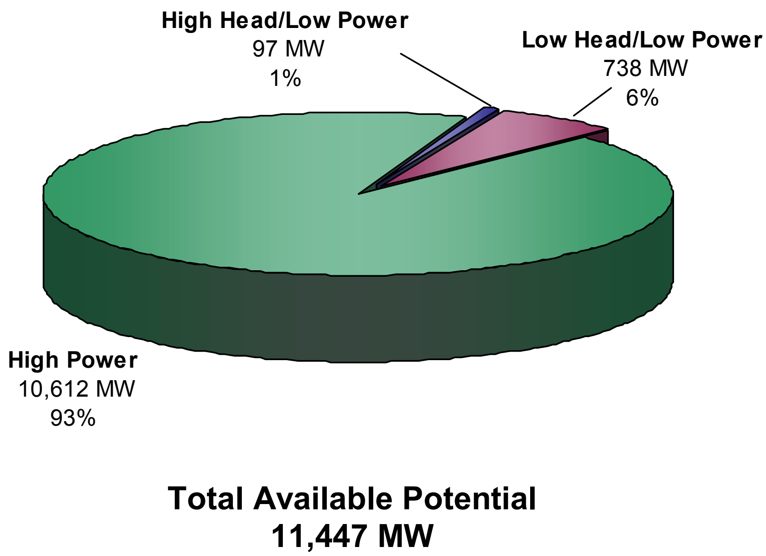


Figure A-38. Power class distribution of the available power potential (annual mean power) of water energy resources in the Lower Mississippi Region (HUC 8).

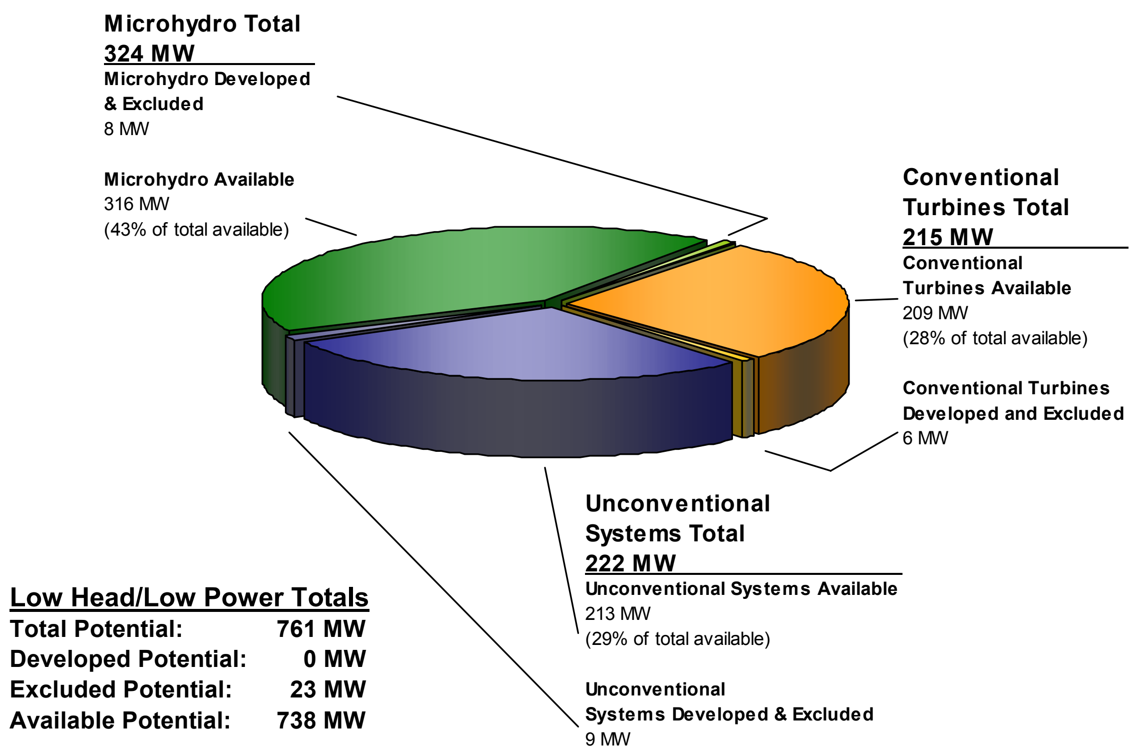


Figure A-39. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Lower Mississippi Region (HUC 8) among three low head/low power hydropower technology classes.

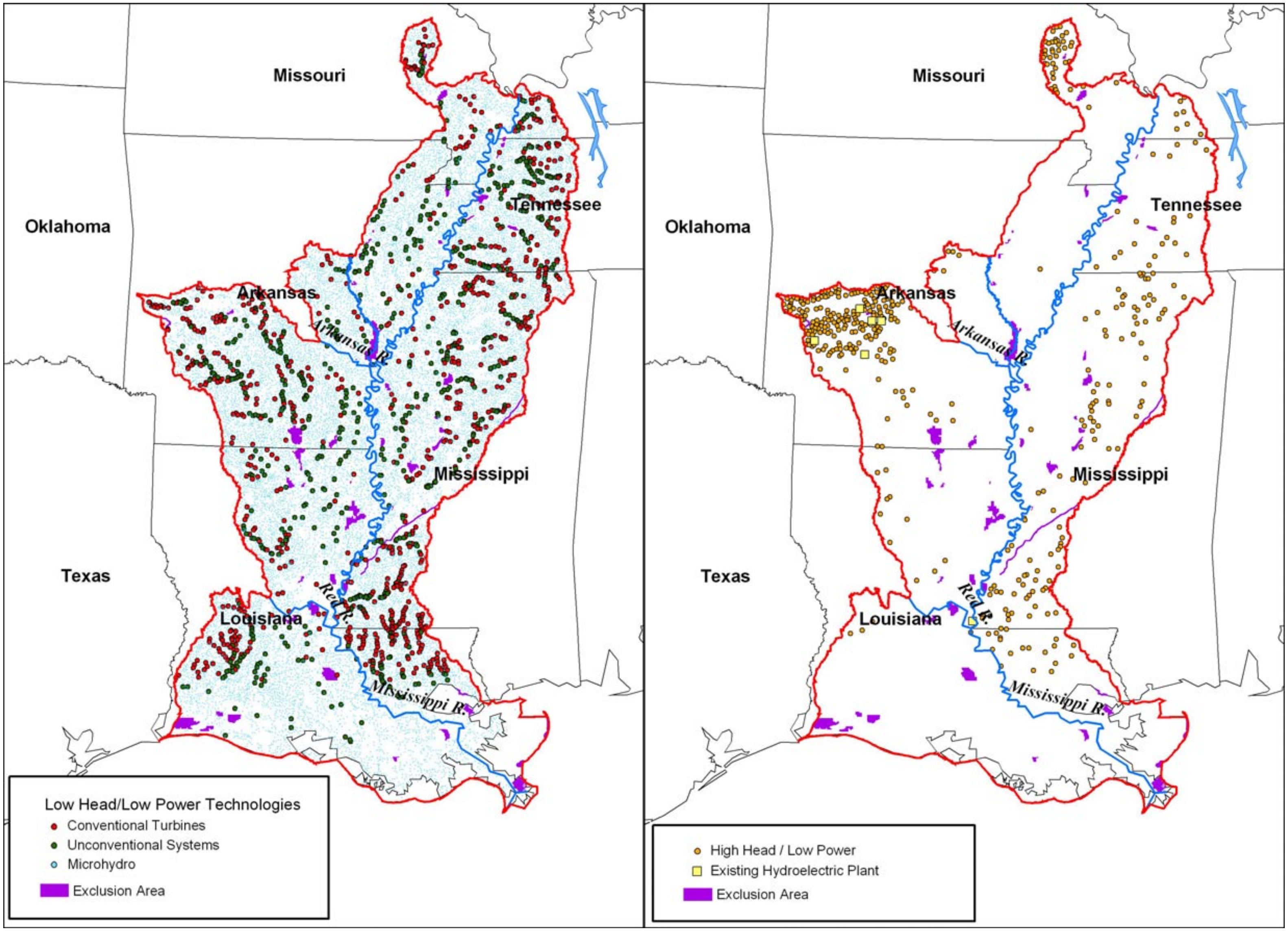


Figure A-40. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Lower Mississippi Region (HUC 8).

A.9 Souris Red-Rainy Region

A.9.1 Region Description

The topographic and hydrographic features of the Souris Red-Rainy Region are shown in Figure A-41. The region covers northern Minnesota, northern and eastern North Dakota and a very small portion of South Dakota. Unlike most of the lower 48 states, the Red, Rainy, and Souris Rivers flow northward into Canada. As a result, this region is the only watershed in the United States that drains into Hudson Bay. The Red River is sometimes called the "Red River of the North" to differentiate it from the Red River in the Arkansas White Red Region (HUC 11).

The region is composed of prairie, coniferous forests, lakes, and wetlands. It is mostly flat and poorly drained in many places. Most of Minnesota's famed "10,000 lakes" are in this region, which contains many small and medium-sized towns, but no major cities. The climate is continental with long cold winters and a short summer growing season.

A.9.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

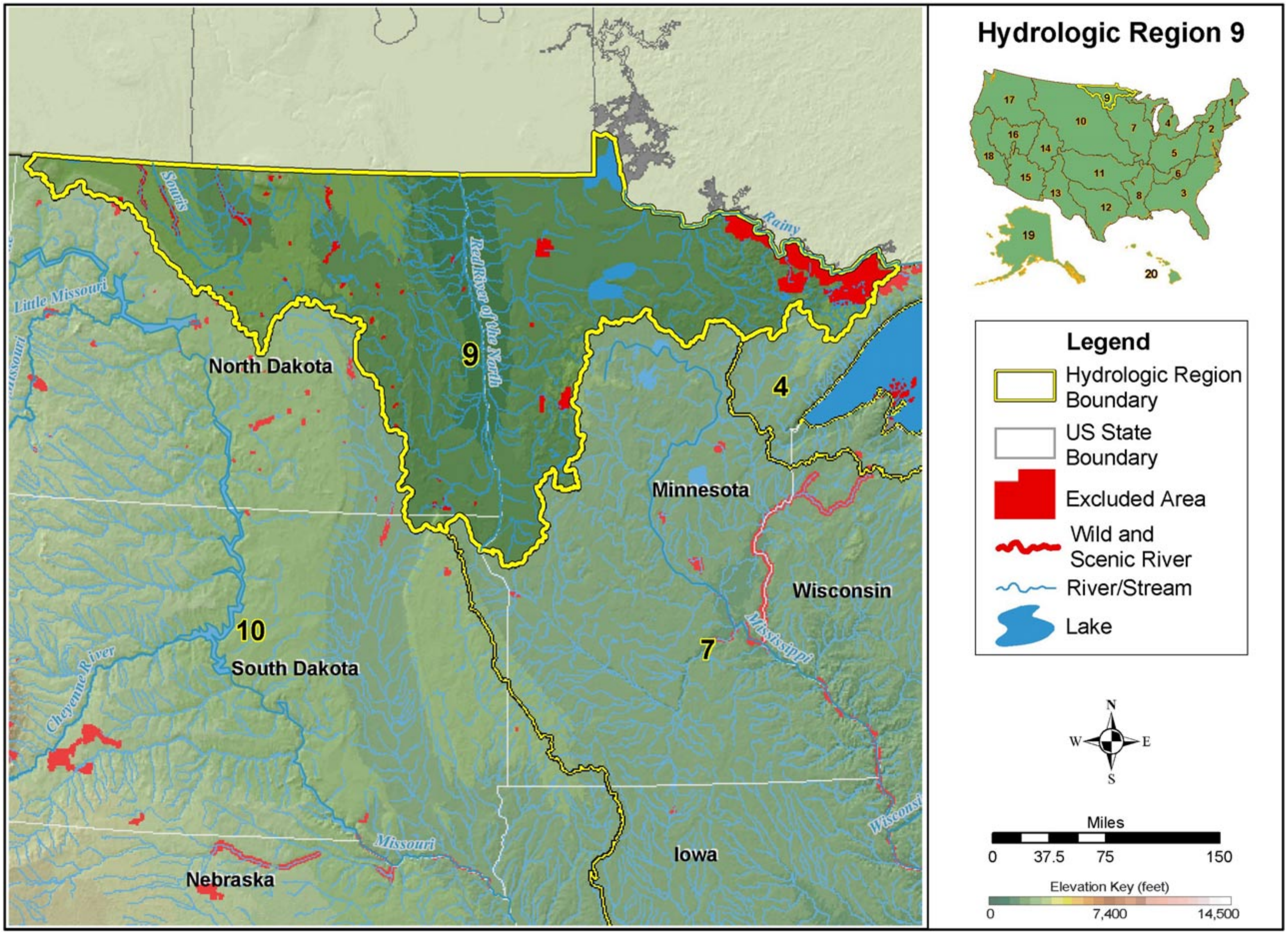


Figure A-41. Souris Red-Rainy Region (HUC 9).

Table A-9. Summary of results of water energy resource assessment of the Souris Red-Rainy Region (HUC 9).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**431**	**12**	**101**	**318**
TOTAL HIGH POWER	**181**	**10**	**63**	**108**
High Head/High Power	**86**	**10**	**28**	**48**
Low Head/High Power	**95**	**0**	**35**	**60**
TOTAL LOW POWER	**250**	**2**	**38**	**210**
High Head/Low Power	**64**	**1**	**18**	**45**
Low Head/Low Power	**186**	**1**	**20**	**165**
Conventional Turbine	57	1	8	48
Unconventional Systems	26	0	4	22
Microhydro	103	0	8	95

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

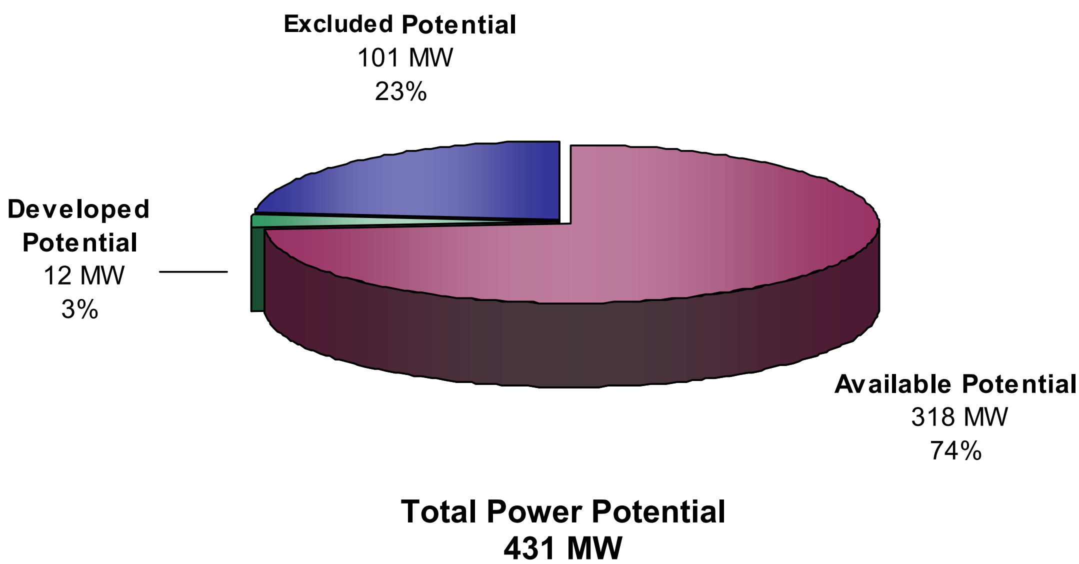


Figure A-42. Power category distribution of the total power potential (annual mean power) of water energy resources in the Souris Red-Rainy Region (HUC 9).

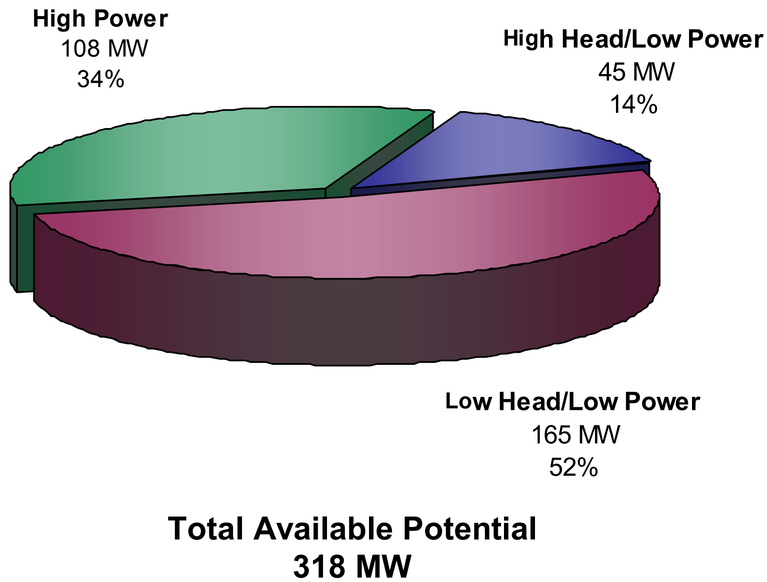


Figure A-43. Power class distribution of the available power potential (annual mean power) of water energy resources in the Souris Red-Rainy Region (HUC 9).

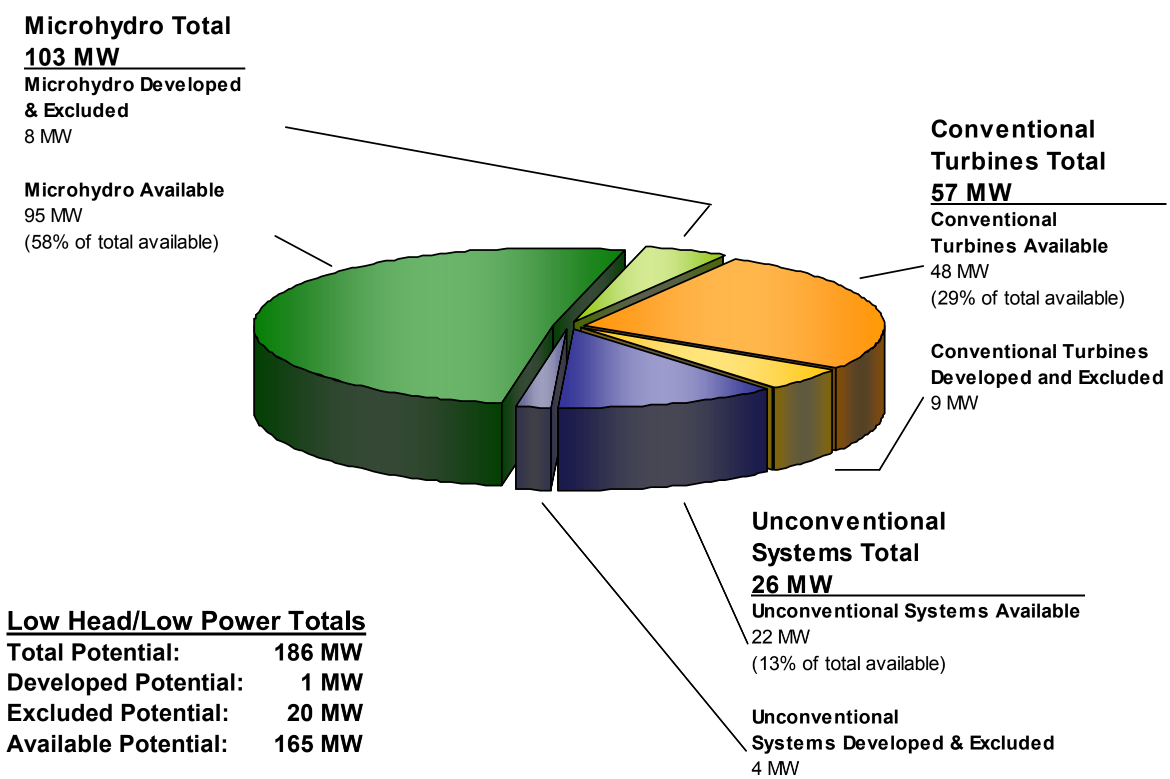


Figure A-44. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Souris Red-Rainy Region (HUC 9) among three low head/low power hydropower technology classes.

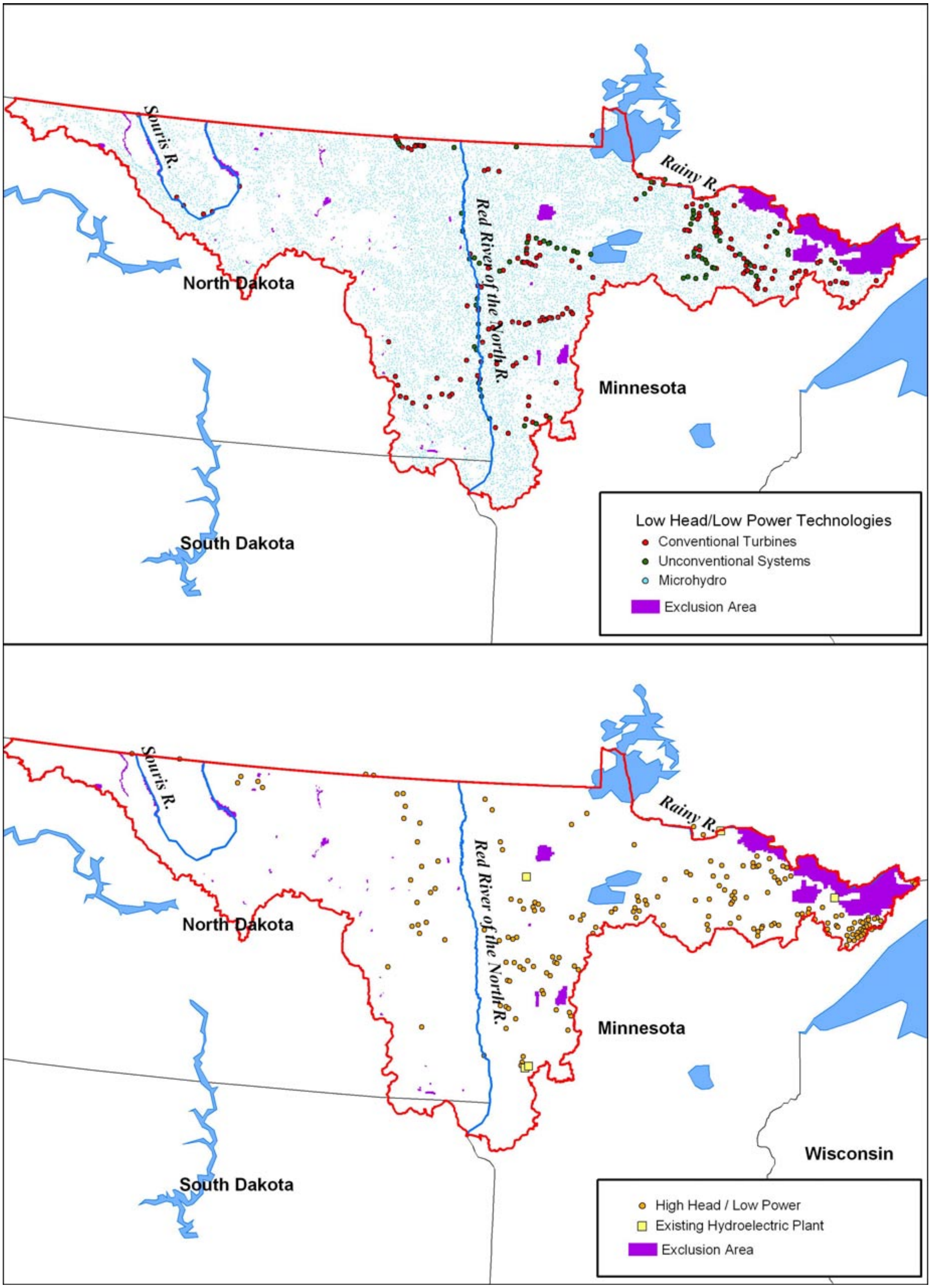


Figure A-45. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Souris Red-Rainy Region (HUC 9).

A.10 Missouri Region

A.10.1 Region Description

The topographic and hydrographic features of the Missouri Region are shown in Figure A-46. The region is by far the largest hydrologic region in the conterminous United States. It coincides with the entire Missouri River watershed up to the Canadian border and covers all of Nebraska, most of Montana, Wyoming, North Dakota, South Dakota, Missouri as well as parts of Colorado, Kansas, Iowa, and Minnesota.

The region extends from the margins of the Ozark Plateau in Missouri through the northern Great Plains to the summits of the Northern Rocky Mountains. The northern Great Plains, a vast, rolling prairie, comprises most of the region. In the south and east, the prairie is less than 1,500 feet above sea level, with elevations gradually but steadily increasing toward the west. For example, the high plains of western Nebraska and Colorado can exceed 5,000 feet in elevation. The region includes several entire mountain ranges including the Black Hills of South Dakota and the Big Horn Mountains of Wyoming. The entire eastern slope of the northern Rocky Mountains is also within this region, including parts of the Front Ranges of Colorado, Yellowstone National Park and Glacier National Park. In eastern Wyoming and southeastern Montana, flat arid plains alternate with disconnected mountain ranges.

The Missouri River is the principal river of this region. The Missouri River plus the lower Mississippi River constitutes the longest waterway in North America. Water from the eastern portions of Yellowstone and Glacier National Parks ultimately discharges into the Gulf of Mexico near New Orleans, Louisiana. Principal tributaries of the Missouri River include (from south to north), the South Platte, North Platte, Sweetwater, Cheyenne, Little Missouri, and Yellowstone Rivers. The Missouri River and its tributaries have been dammed in many places for flood control, water supply, and hydropower purposes. The largest of these include Ft. Peck Reservoir, Lake Sakakawea, Lake Ohae, and Lake Francis Case, which create a series of elongated lakes (up to 200 mi. long) along the path of the Missouri River in Montana, North Dakota, and South Dakota.

The climate becomes gradually drier toward the west, with semi-arid steppe landscapes dominating the flat portions of eastern Wyoming and Montana. The climate in the northern plains and Rocky Mountains is severe with long, cold, winters and short summers. In the southeastern portions of the region, the climate is more temperate with long, hot summers.

A.10.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

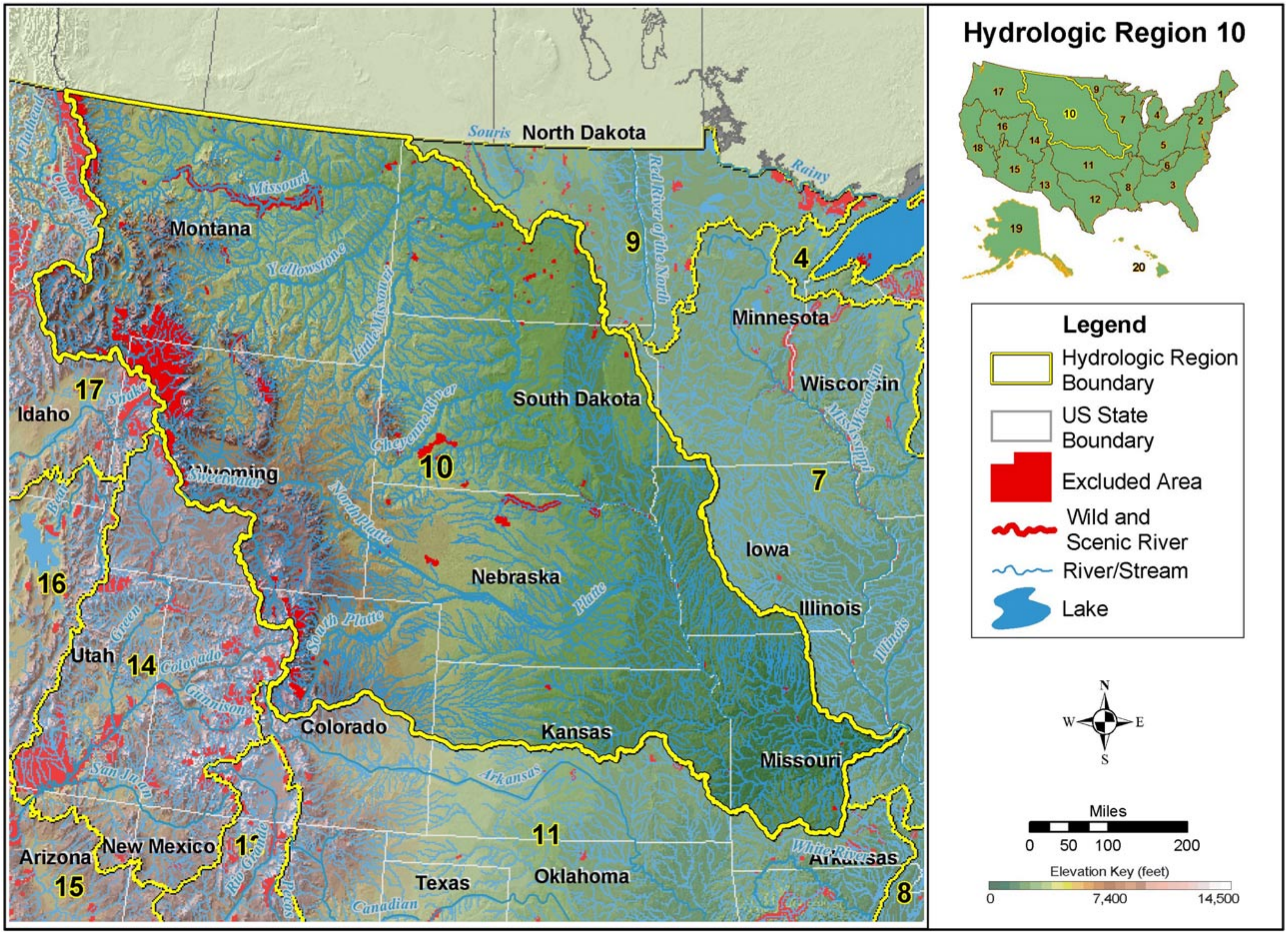


Figure A-46. Missouri Region (HUC 10).

Table A-10. Summary of results of water energy resource assessment of the Missouri Region (HUC 10).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**15,823**	**1,797**	**4,622**	**9,404**
TOTAL HIGH POWER	**10,370**	**1,788**	**3,830**	**4,752**
High Head/High Power	**7,538**	**1,780**	**3,533**	**2,225**
Low Head/High Power	**2,832**	**8**	**297**	**2,527**
TOTAL LOW POWER	**5,453**	**9**	**792**	**4,652**
High Head/Low Power	**2,512**	**8**	**658**	**1,846**
Low Head/Low Power	**2,941**	**1**	**134**	**2,806**
Conventional Turbine	1,157	1	66	1,090
Unconventional Systems	370	0	30	340
Microhydro	1,414	0	38	1,376

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

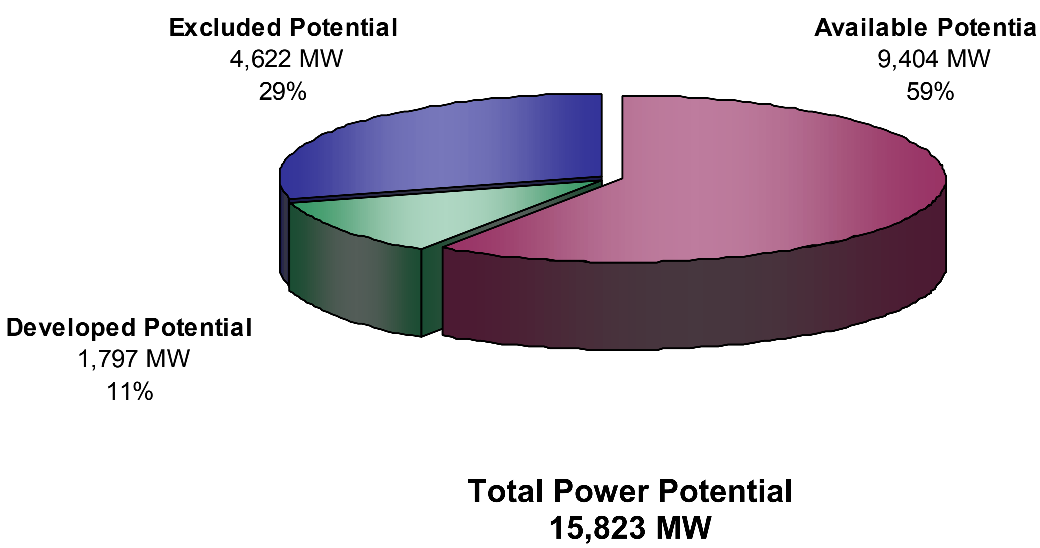


Figure A-47. Power category distribution of the total power potential (annual mean power) of water energy resources in the Missouri Region (HUC 10).

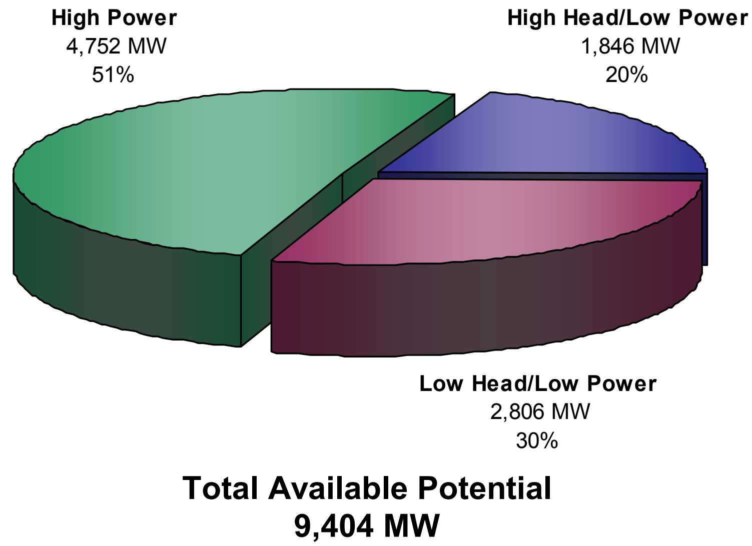


Figure A-48. Power class distribution of the available power potential (annual mean power) of water energy resources in the Missouri Region (HUC 10).

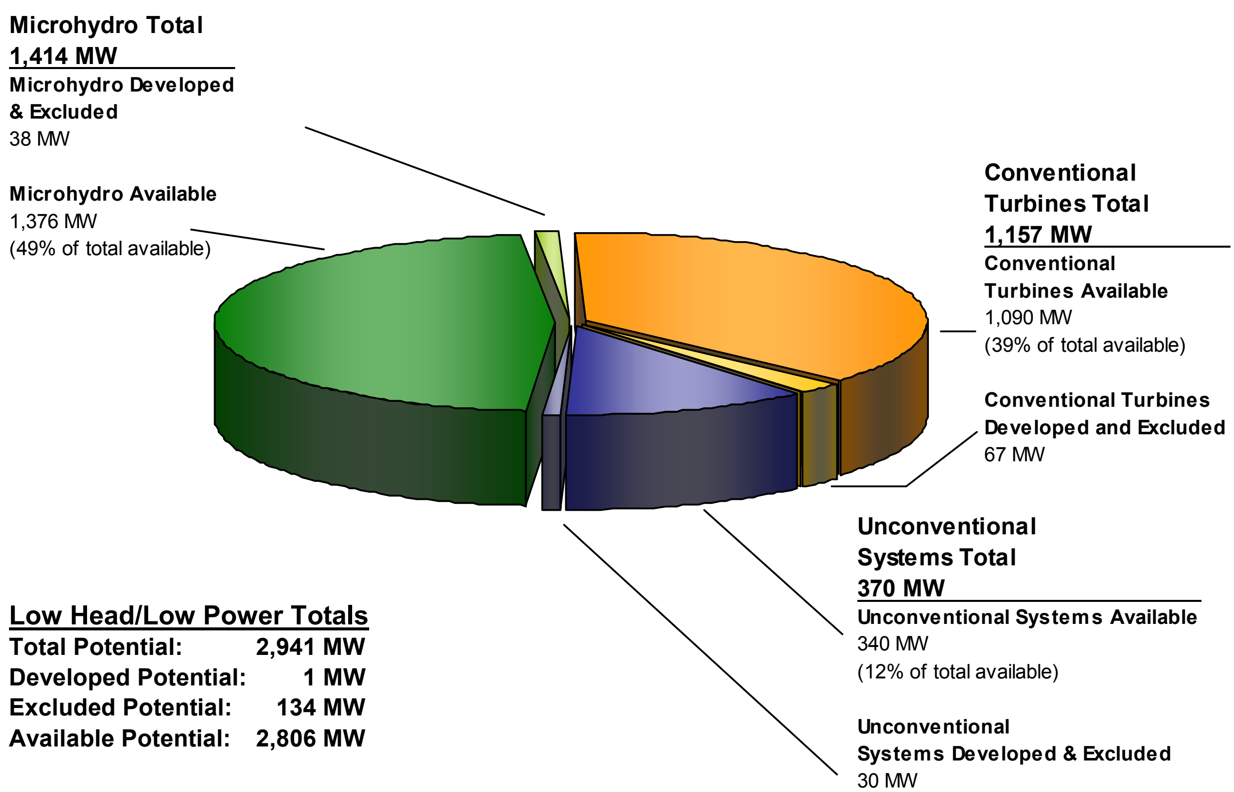


Figure A-49. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Missouri Region (HUC 10) among three low head/low power hydropower technology classes.

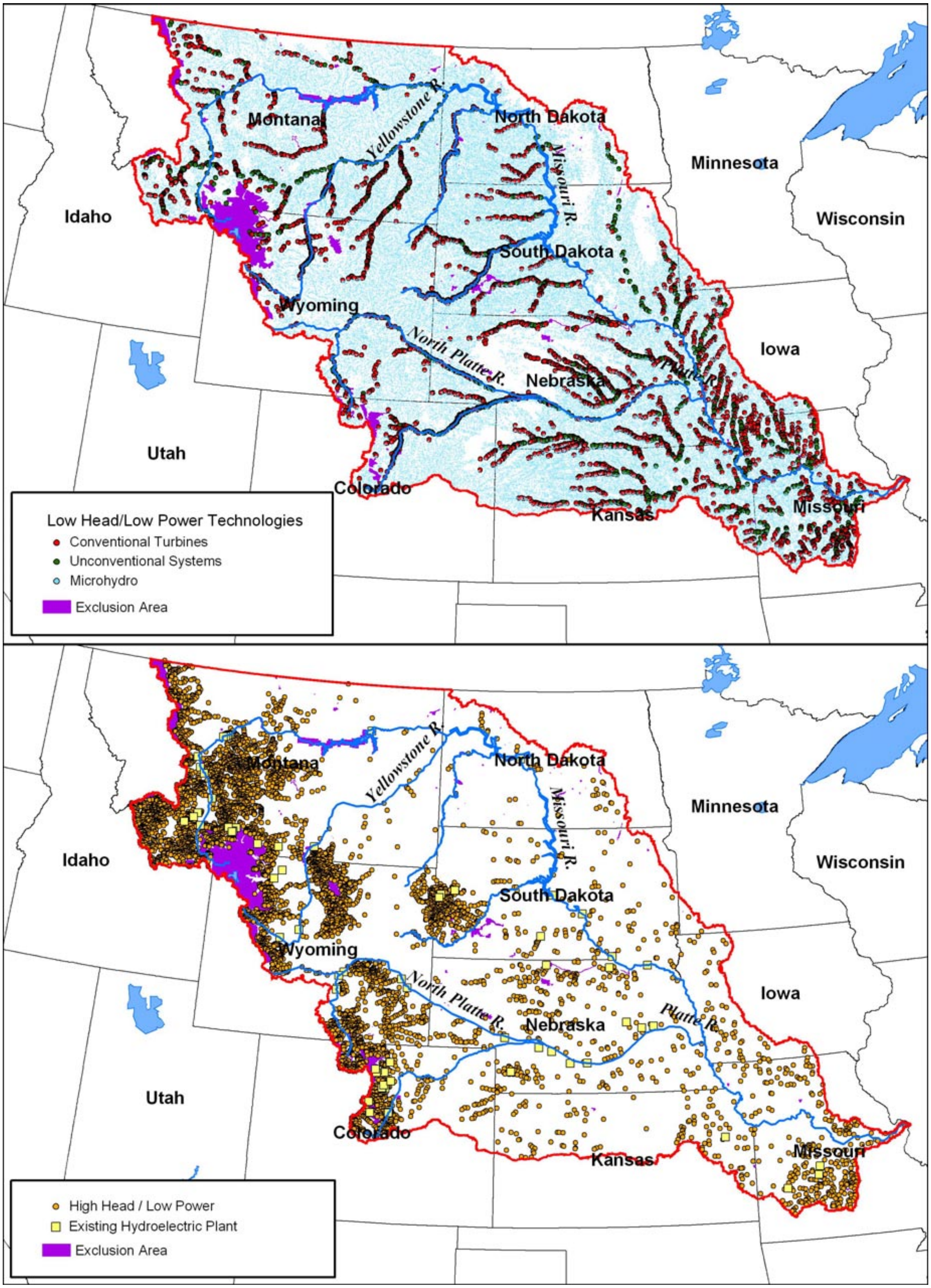


Figure A-50. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Missouri Region (HUC 10).

A.11 Arkansas-White-Red Region

A.11.1 Region Description

The topographic and hydrographic features of the Arkansas-White-Red (AWR) Region are shown in Figure A-51. The region is composed of three watersheds: the Arkansas River and its major tributary, the Canadian River; the Red River; and the White River. The AWR Region covers the entire State of Oklahoma as well as portions of seven nearby states (Texas, New Mexico, Colorado, Kansas, Missouri, Arkansas, and Louisiana).

The topography over much of the AWR Region is relatively flat with some notable exceptions. Most of the region falls within the southern Great Plains and is characterized by either flat plains or rolling hills broken by stream floodplains. Higher relief is found in the Ozark Plateau and Ouachita Mountains in the eastern portion of the region where the states of Arkansas, Oklahoma, and Missouri meet. The westernmost part of the region extends all the way to the headwaters of the Arkansas and Canadian Rivers. The upper portions of these watersheds border the continental divide in Colorado and New Mexico. This part of the AWR Region contains topography characteristic of the southern Rocky Mountains: high plateaus and mountains incised by steep canyons and separated by deep valleys.

In the southern half of the AWR Region, the climate is warm, with hot summers and mild winters. The northern half of the region experiences great seasonal extremes of weather, subject to cold winters and hot summers. Colliding air masses from the north and south create sudden temperature changes, blizzards, severe thunderstorms, and tornadoes. The eastern half of the region is humid, but becomes increasingly dry toward the west.

A.11.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

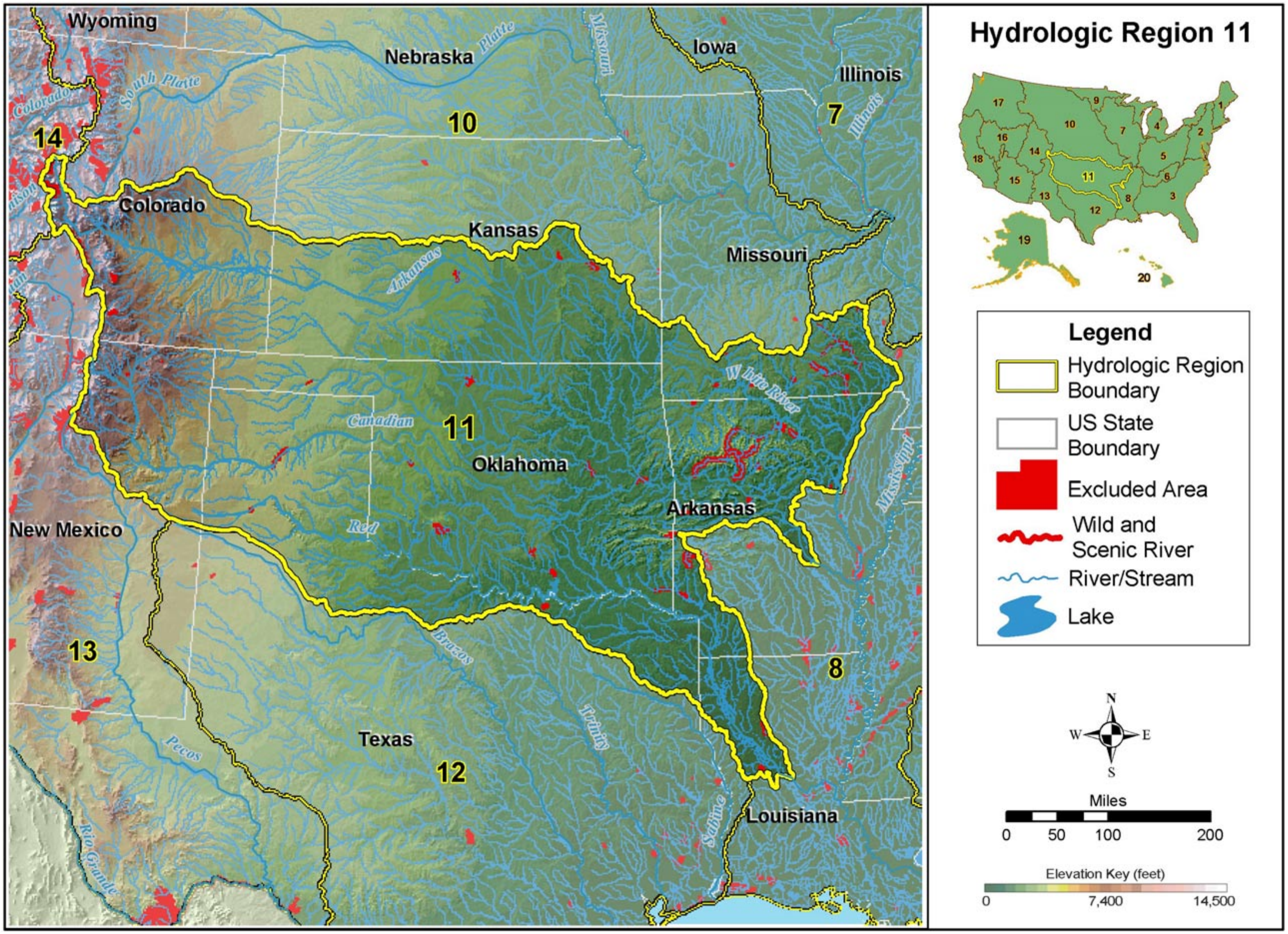


Figure A-51. Arkansas-White-Red Region (HUC 11).

Table A-11. Summary of results of water energy resource assessment of Arkansas-White-Red Region (HUC 11).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**5,053**	**696**	**329**	**4,028**
TOTAL HIGH POWER	**2,364**	**693**	**136**	**1,535**
High Head/High Power	**871**	**596**	**86**	**189**
Low Head/High Power	**1,493**	**97**	**50**	**1,346**
TOTAL LOW POWER	**2,689**	**3**	**193**	**2,493**
High Head/Low Power	**802**	**3**	**105**	**694**
Low Head/Low Power	**1,887**	**0**	**88**	**1,799**
Conventional Turbine	762	0	41	721
Unconventional Systems	351	0	22	329
Microhydro	774	0	25	749

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

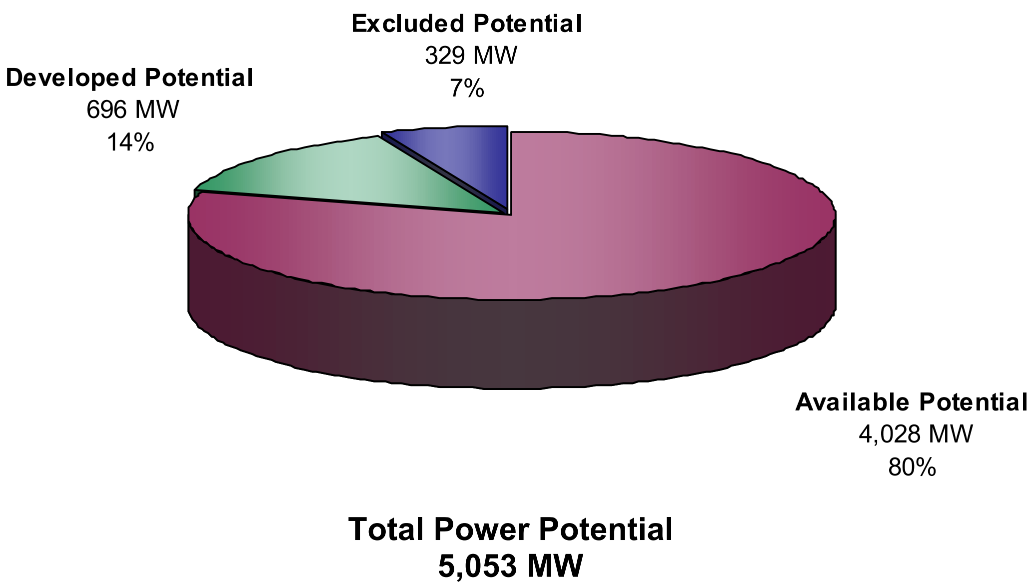


Figure A-52. Power category distribution of the total power potential (annual mean power) of water energy resources in the Arkansas-White-Red Region (HUC 11).

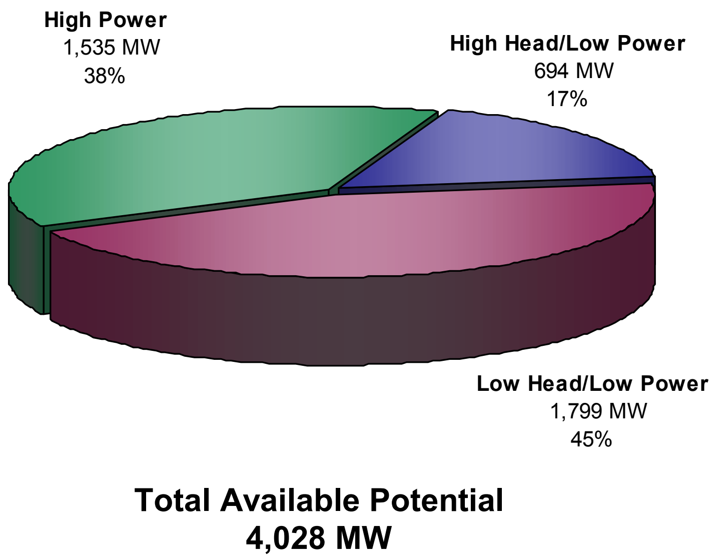


Figure A-53. Power class distribution of the available power potential (annual mean power) of water energy resources in the Arkansas-White-Red Region (HUC 11).

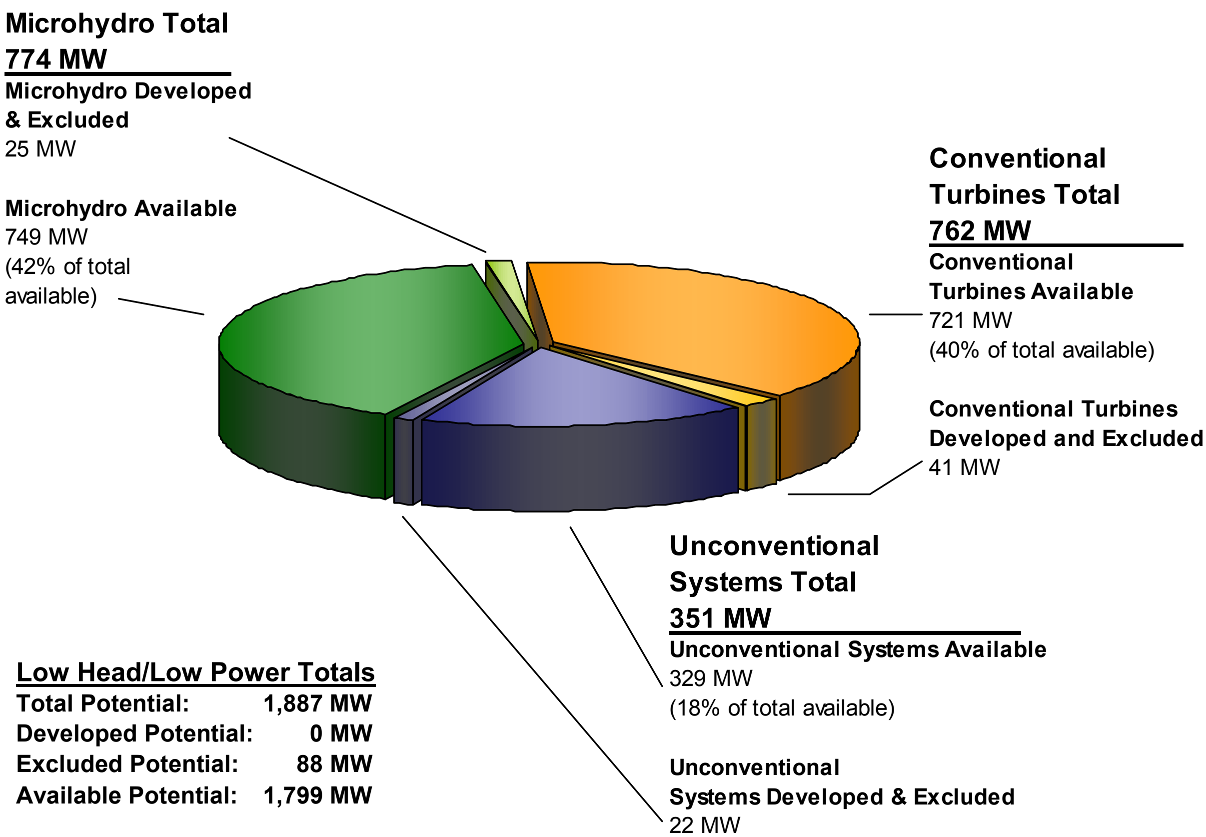


Figure A-54. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Arkansas-White-Red Region (HUC 11) among three low head/low power hydropower technology classes.

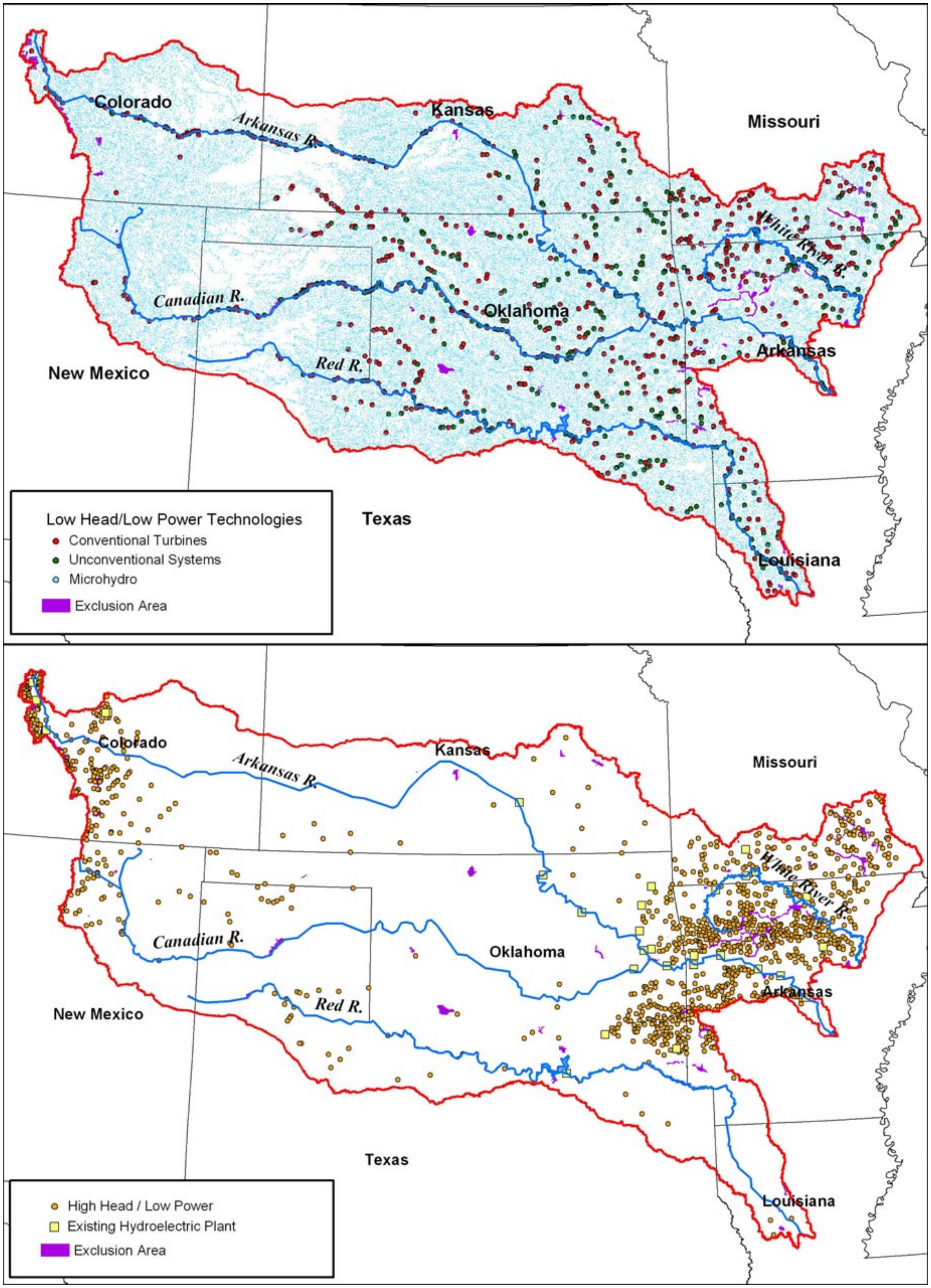


Figure A-55. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Arkansas-White-Red Region (HUC 11).

A.12 Texas-Gulf Region

A.12.1 Region Description

The topographic and hydrographic features of the Texas-Gulf Region are shown in Figure A-56. The region coincides with most of the State of Texas, except for the Red River Valley, the Rio Grande Valley, the panhandle, and West Texas. Small portions of western Louisiana and eastern New Mexico are also included in this region. Landscapes vary from swamps and bayous along the Gulf Coast near Louisiana to pine and cypress forests and lush grasslands in the remainder of East Texas. The eastern portion consists of flat, fertile plains with ample rainfall. Toward the west, the land passes through the Texas Hill Country before rising stepwise to the tablelands of the Edwards Plateau (750 to 2,000 feet in elevation), and finally to the Llano Estacado, a high, dry, desolate, windswept plain along the Texas-New Mexico state line.

Several moderate-sized rivers drain the region, emptying directly into the Gulf of Mexico. These include the Brazos, Trinity, and Sabine Rivers. Hydropower projects have been built on all these rivers.

The climate becomes increasing arid toward the west. The southern portions of the region are warm enough to support citrus orchards.

A.12.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

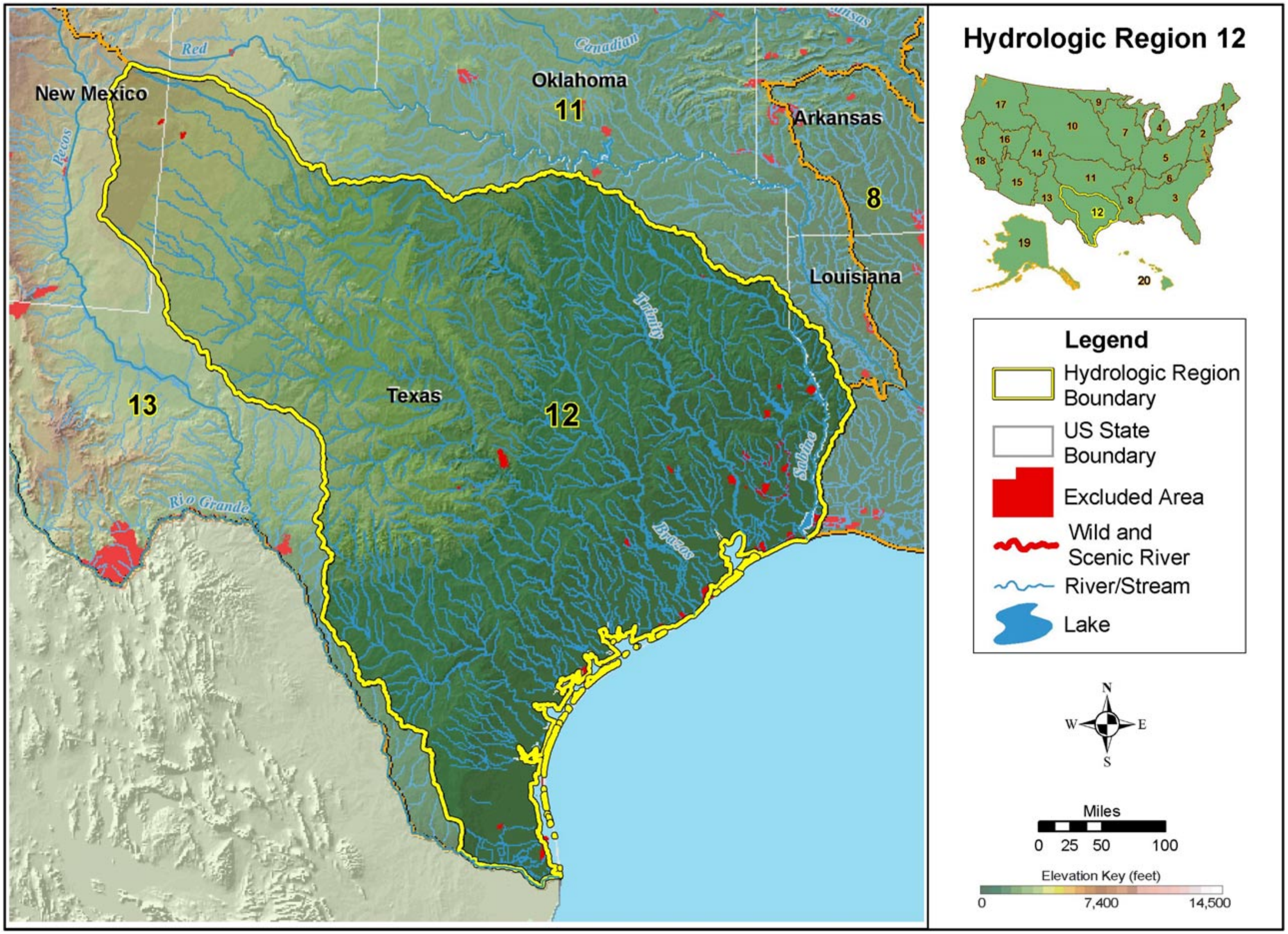


Figure A-56. Texas-Gulf Region (HUC 12).

Table A-12. Summary of results of water energy resource assessment of the Texas-Gulf Region (HUC 12).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**1,811**	**127**	**61**	**1,623**
TOTAL HIGH POWER	**523**	**121**	**39**	**363**
High Head/High Power	**209**	**116**	**2**	**91**
Low Head/High Power	**314**	**5**	**37**	**272**
TOTAL LOW POWER	**1,288**	**6**	**22**	**1,260**
High Head/Low Power	**196**	**1**	**2**	**193**
Low Head/Low Power	**1,092**	**5**	**20**	**1,067**
Conventional Turbine	330	5	5	320
Unconventional Systems	188	0	9	179
Microhydro	574	0	6	568

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

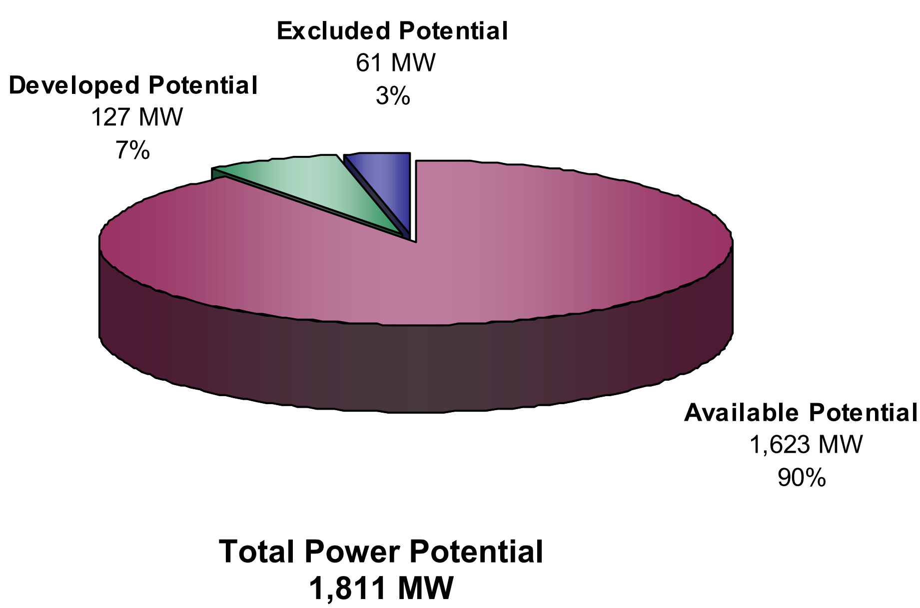


Figure A-57. Power category distribution of the total power potential (annual mean power) of water energy resources in the Texas-Gulf Region (HUC 12).

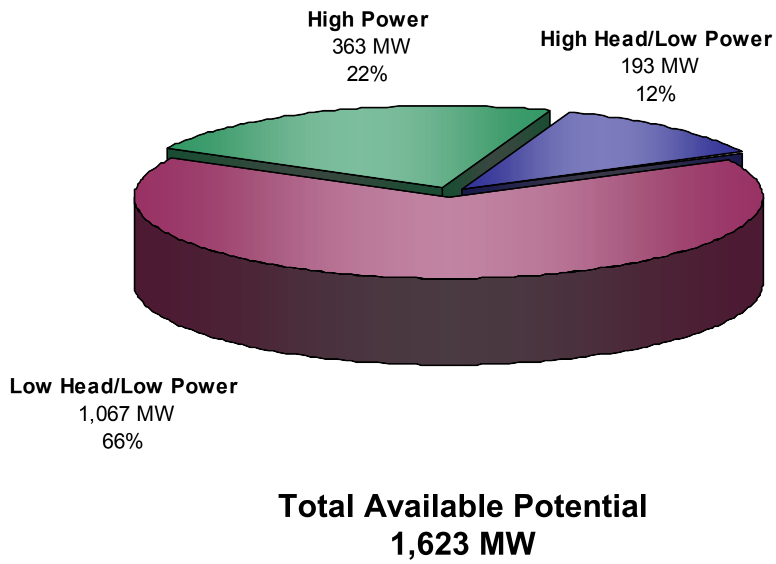


Figure A-58. Power class distribution of the available power potential (annual mean power) of water energy resources in the Texas-Gulf Region (HUC 12).

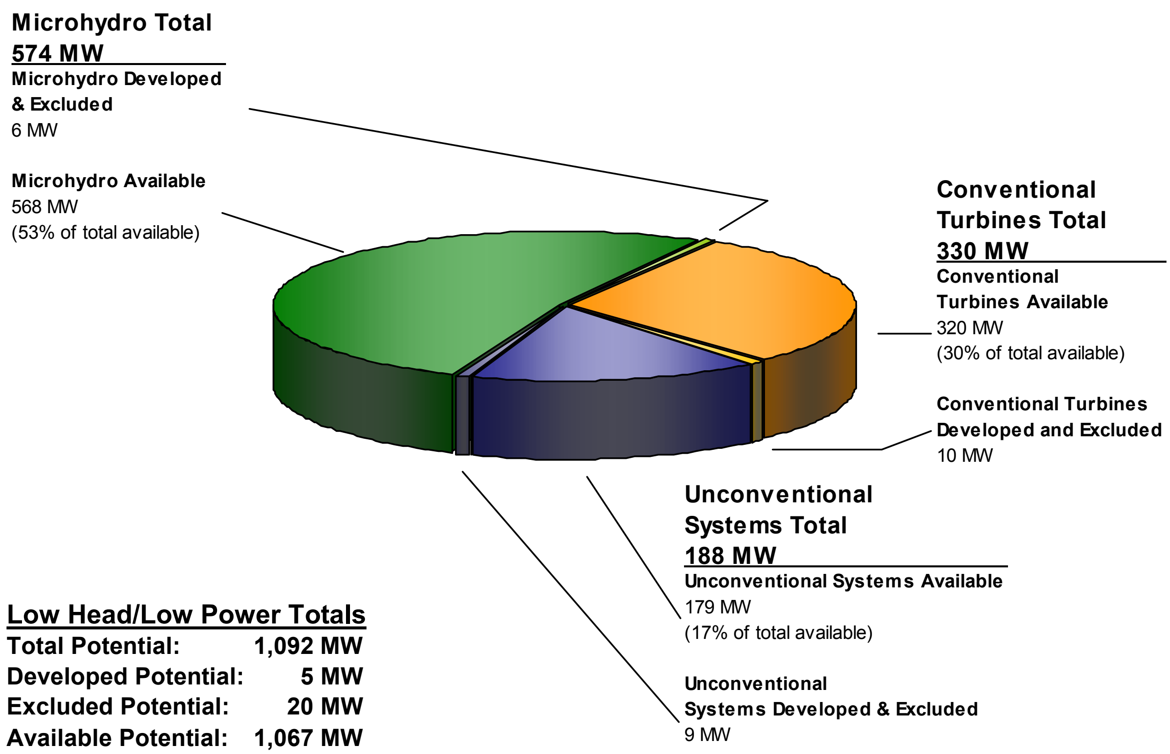
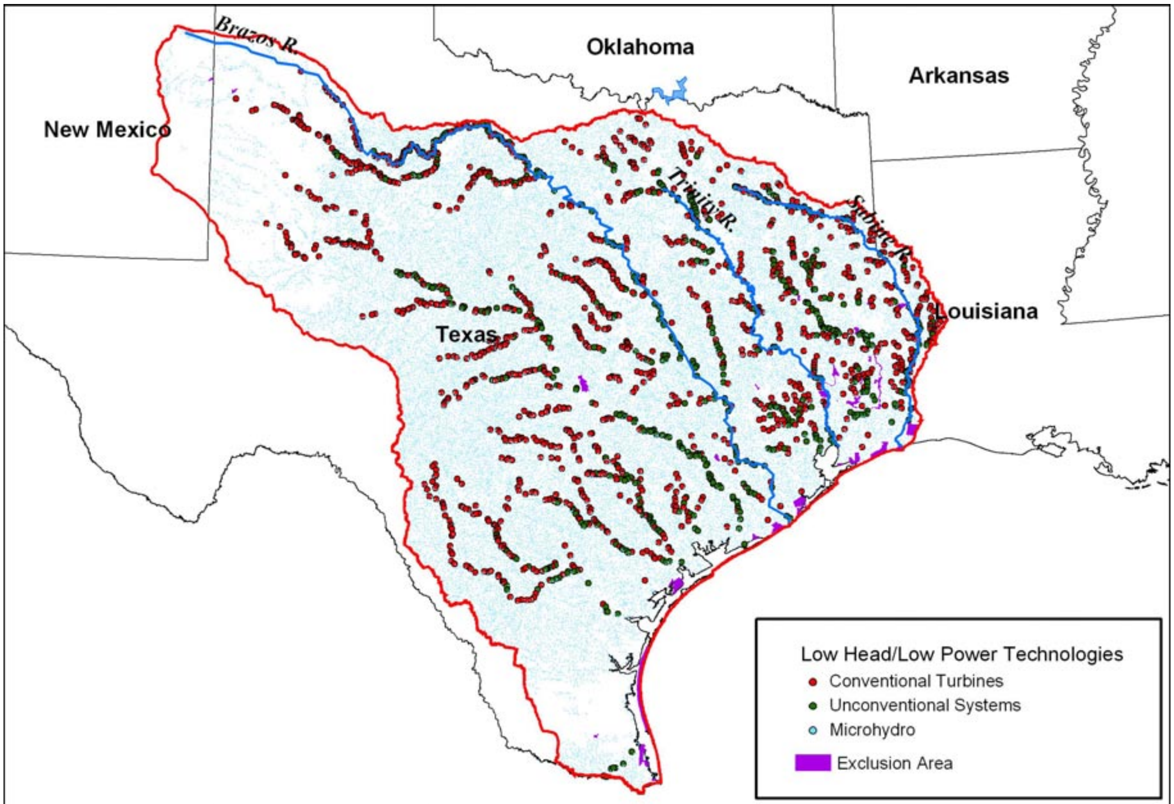


Figure A-59. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Texas-Gulf Region (HUC 12) among three low head/low power hydropower technology classes.



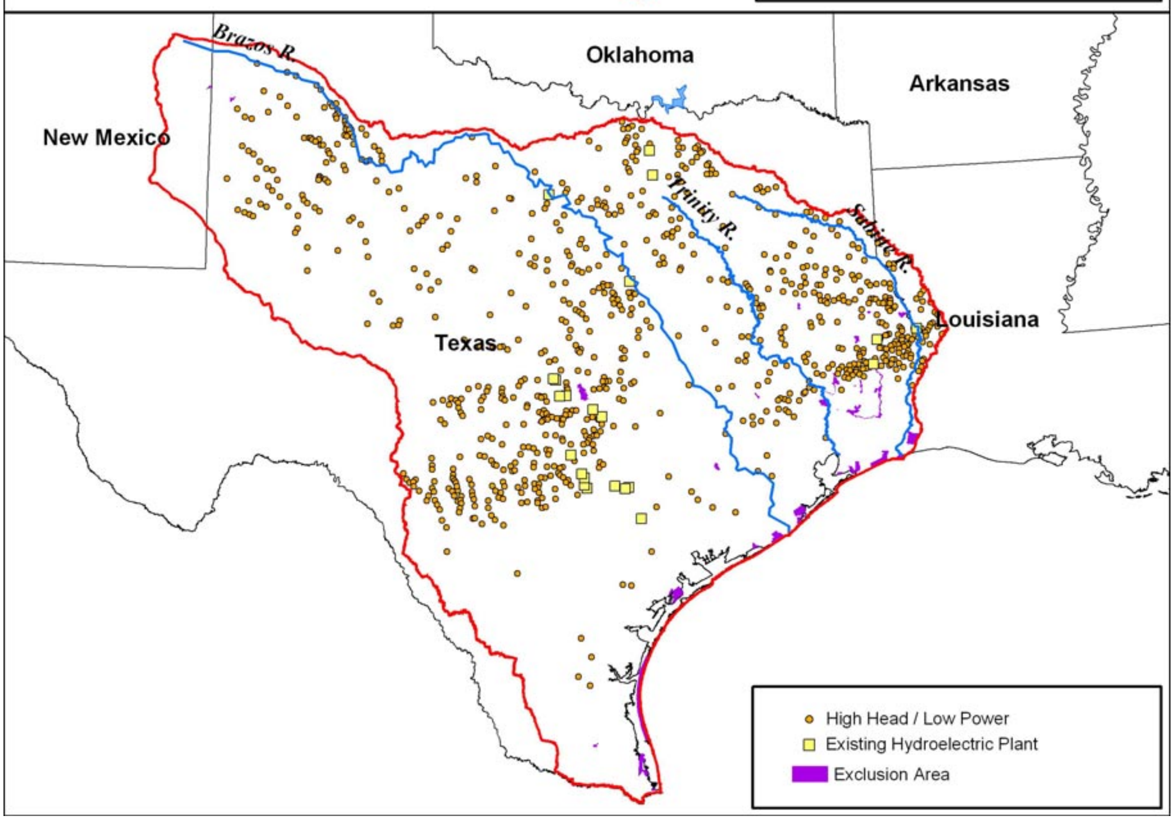


Figure A-60. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Texas-Gulf Region (HUC 12).

A.13 Rio Grande Region

A.13.1 Region Description

The topographic and hydrographic features of the Rio Grande Region are shown in Figure A-61. The region includes the entire Rio Grande watershed north of the United States-Mexican border. It extends from the Gulf of Mexico to the Continental Divide, covering most of New Mexico, part of south-central Colorado, much of west Texas, as well as a narrow strip of Texas along the Mexican border.

The headwaters of the Rio Grande River are found in the San Juan Mountains, a high mountain range in southern Colorado. The Rio Grande flows southward into New Mexico, where it bisects the state in a north-south trending tectonic rift valley. The Pecos River, the principal tributary of the Rio Grande, originates in northern New Mexico near Santa Fe to join the Rio Grande in west Texas. The Rio Grande skirts the mountains of west Texas before entering the Gulf Plain, a broad coastal plain bordering the Gulf of Mexico.

The climate in Colorado, New Mexico, and west Texas is generally dry, with arid to semi-arid brushland and steppe dominating. More precipitation falls in the high mountains of northern New Mexico and southern Colorado, where elevations can exceed 13,000 feet. The climate becomes more humid toward the Gulf Coast.

A.13.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

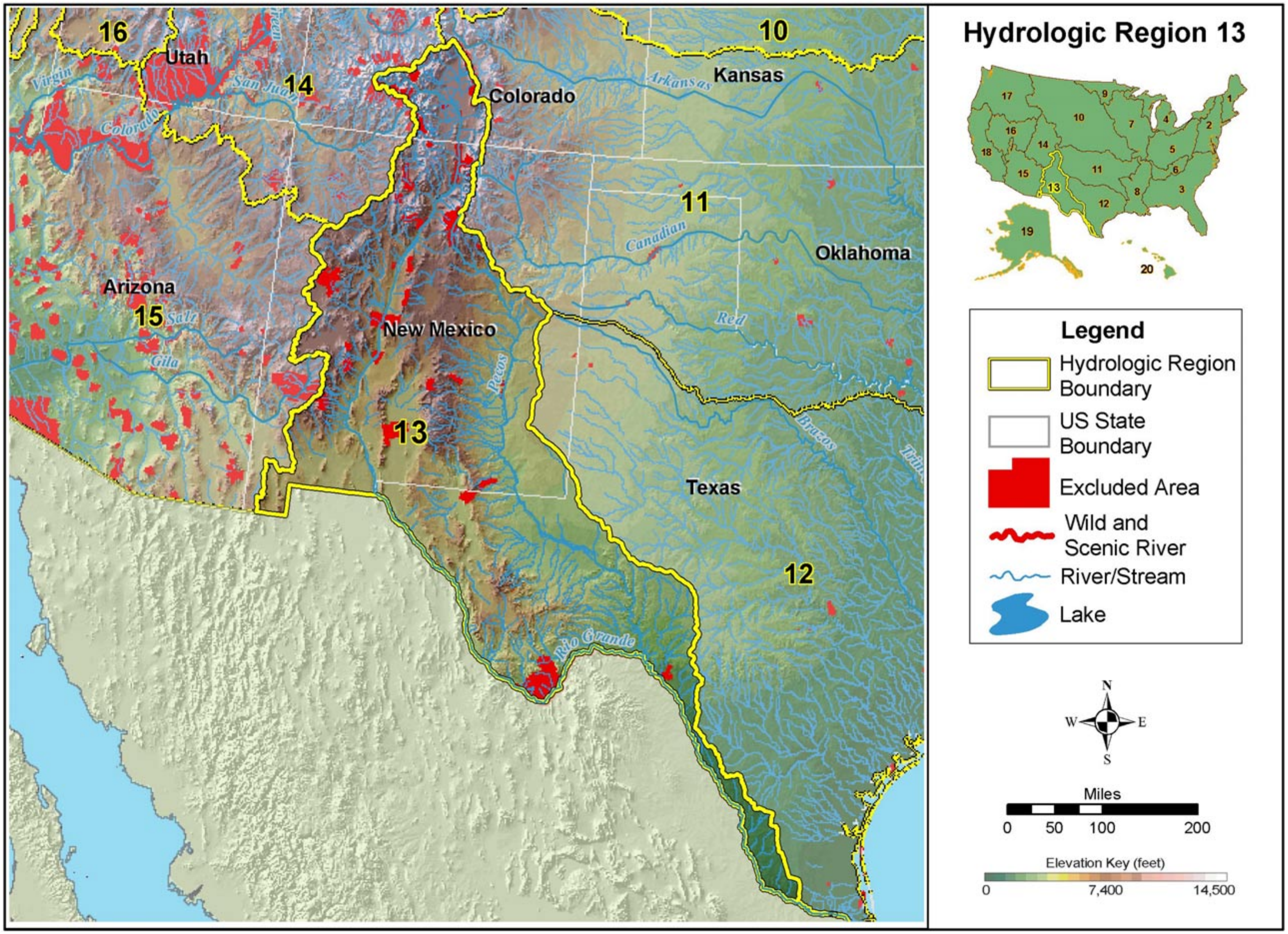


Figure A-61. Rio Grande Region (HUC 13).

Table A-13. Summary of results of water energy resource assessment of the Rio Grande Region (HUC 13).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**2,122**	**50**	**602**	**1,470**
TOTAL HIGH POWER	**811**	**50**	**385**	**376**
High Head/High Power	**721**	**50**	**354**	**317**
Low Head/High Power	**90**	**0**	**31**	**59**
TOTAL LOW POWER	**1,311**	**0**	**217**	**1,094**
High Head/Low Power	**697**	**0**	**167**	**530**
Low Head/Low Power	**614**	**0**	**50**	**564**
Conventional Turbine	177	0	18	159
Unconventional Systems	87	0	9	78
Microhydro	350	0	23	327

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

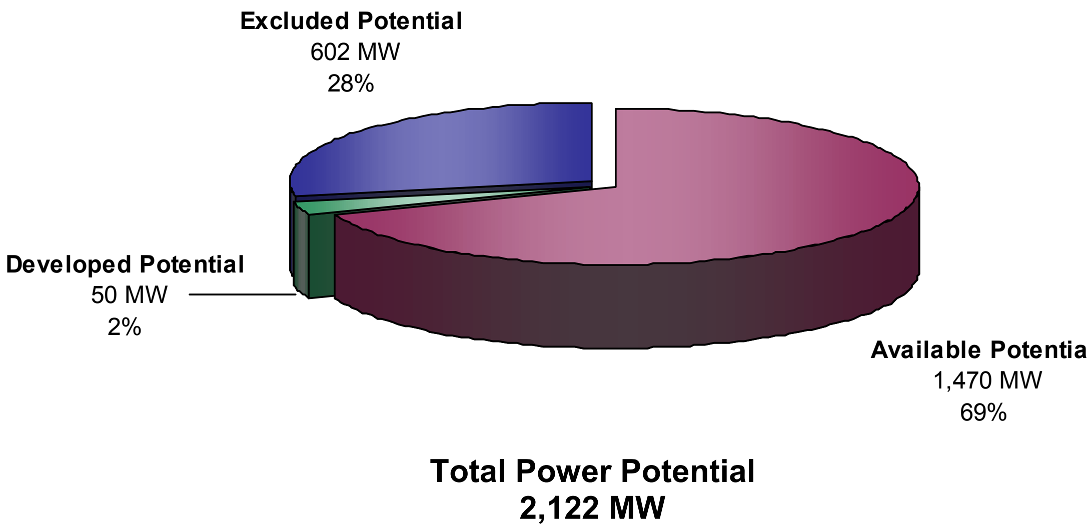


Figure A-62. Power category distribution of the total power potential (annual mean power) of water energy resources in the Rio Grande Region (HUC 13).

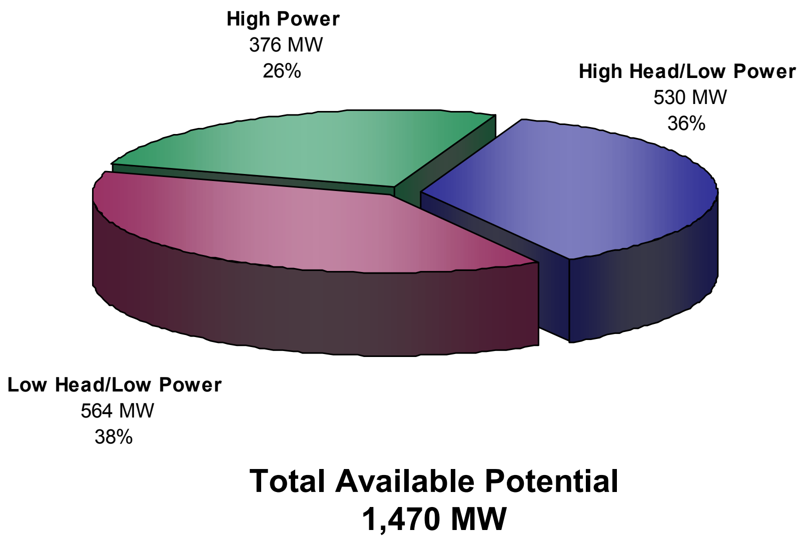


Figure A-63. Power class distribution of the available power potential (annual mean power) of water energy resources in the Rio Grande Region (HUC 13).

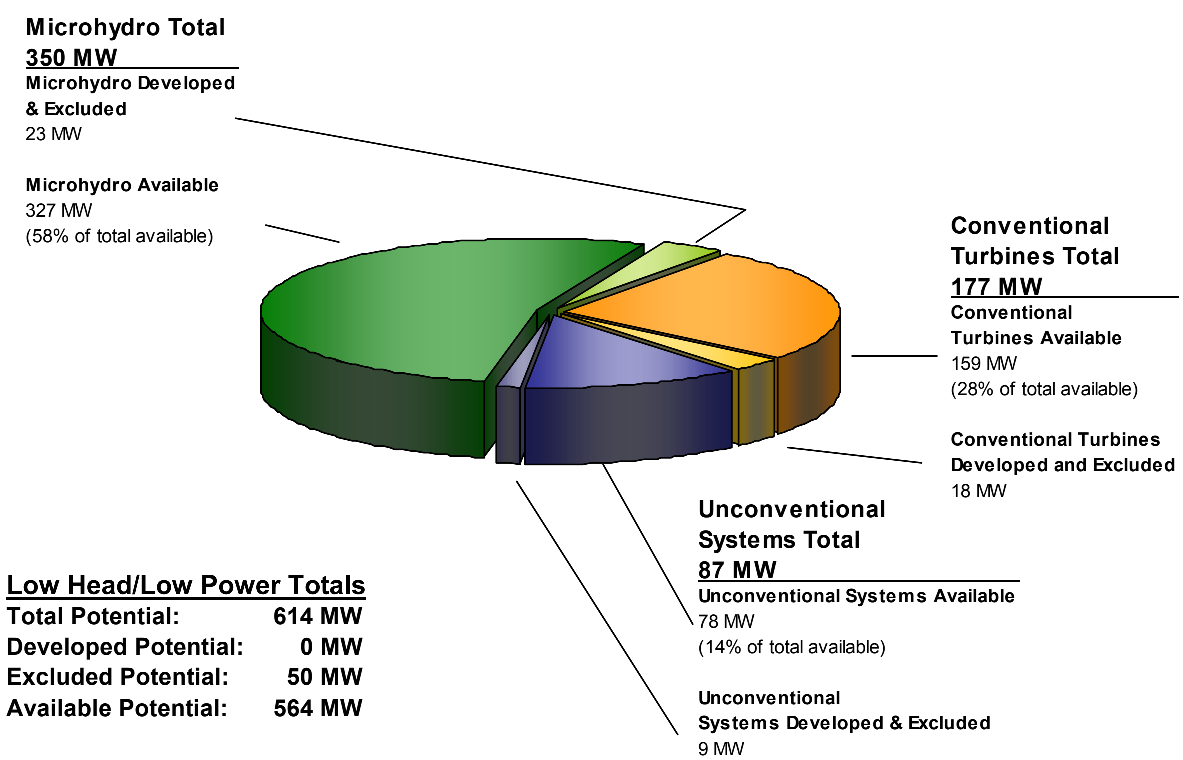


Figure A-64. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Rio Grande Region (HUC 13) among three low head/low power hydropower technology classes.

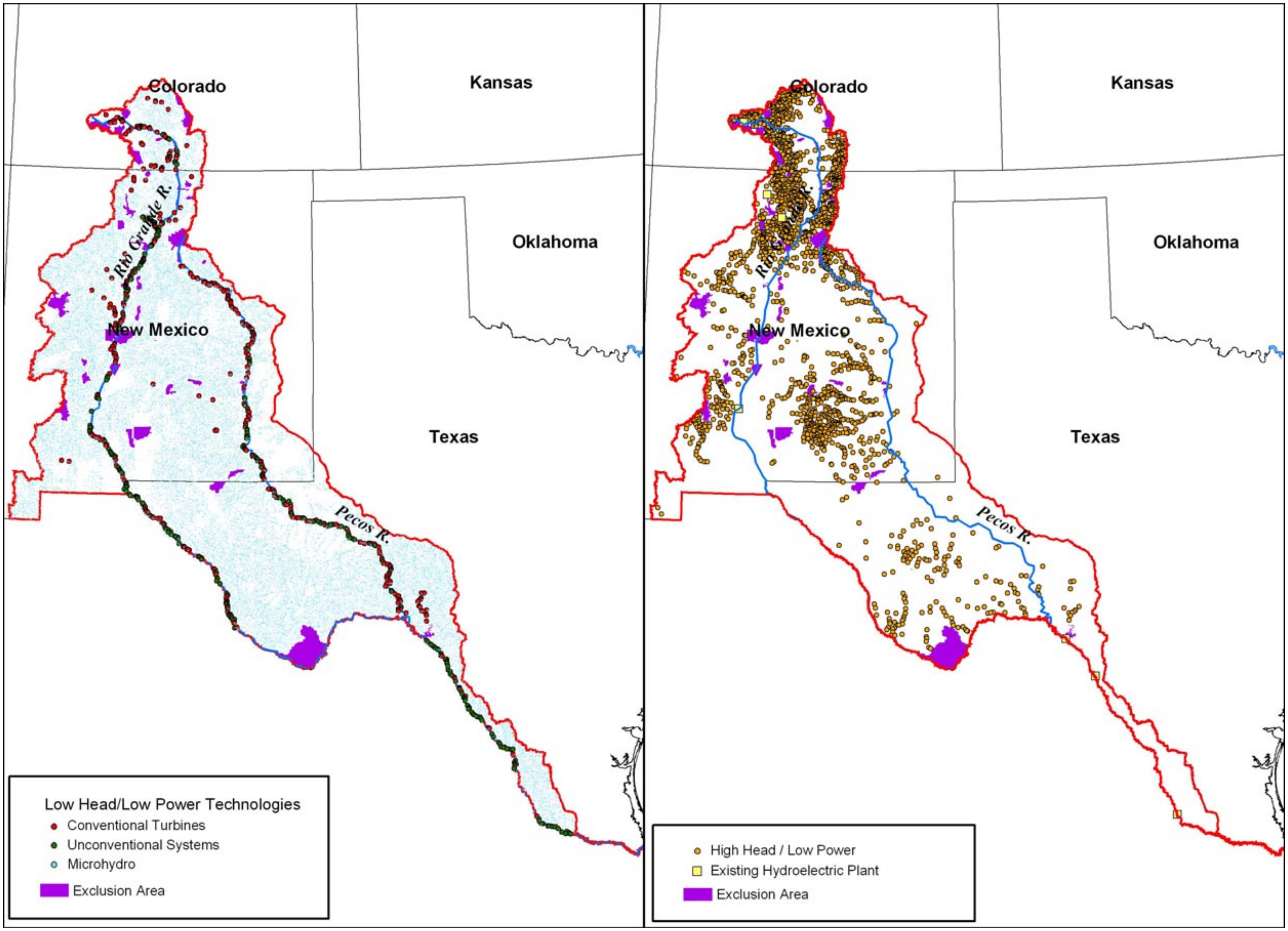


Figure A-65. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Rio Grande Region (HUC 13).

A.14 Upper Colorado Region

A.14.1 Region Description

The topographic and hydrographic features of the Upper Colorado Region are shown in Figure A-66. The region occupies the eastern half of Utah, the western half of Colorado, the southwestern quarter of Wyoming, and portions of northern Arizona and New Mexico. The Colorado Plateau covers the southwestern portion of this region while the Rocky Mountains occupy the eastern and northern portions. The Colorado Plateau, approximately 3,000 to 7,000 feet in elevation, consists of extensive layers of sedimentary rocks. Wind and water erosion of these brightly colored horizontal rock layers have formed a series of buttes, mesas, and cliffs renown for their austere scenic beauty.

Two major rivers, the Colorado River and its principal tributary, the Green River, drain the Upper Colorado Region. Other tributaries include the Gunnison River in Colorado and the San Juan River, which flows through the Four Corners area. In many areas the rivers have carved deep step-like canyons into the plateau. Some canyons are over 3,000 feet deep.

Two major canyons have been dammed for hydropower projects. Glen Canyon Dam, on the Colorado River on the Arizona-Utah border, has created Lake Powell, which extends some 200 miles into southern Utah. Flaming Gorge Reservoir, on the middle reach of the Green River, straddles the Utah-Wyoming state line. Other parts of the region, including portions of the Colorado and Green Rivers, are preserved in national parks, monuments, and recreation areas, where future hydropower development is unlikely. Indian reservations occupy significant portions of the Upper Colorado Region, including the Navajo and Hopi reservations in the Four Corners area and the Uinta-Ouray Reservation in Eastern Utah.

In general, the Upper Colorado Region is arid and sparsely populated, with predominantly desert and steppe environments. East and north of the Colorado Plateau, flat rock layers give way to complexly folded and deformed rocks of the Rocky Mountains. Elevations of 8,000 feet or higher are common with many peaks in Colorado exceeding 14,000 feet. Precipitation levels are higher in the mountainous portions of the region due to orographic effects. Vegetation here includes coniferous forests and high-mountain meadows. These relatively wetter mountain areas give rise to the headwaters of both the Colorado and Green Rivers.

A.14.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class

- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)

- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)

- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes

- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

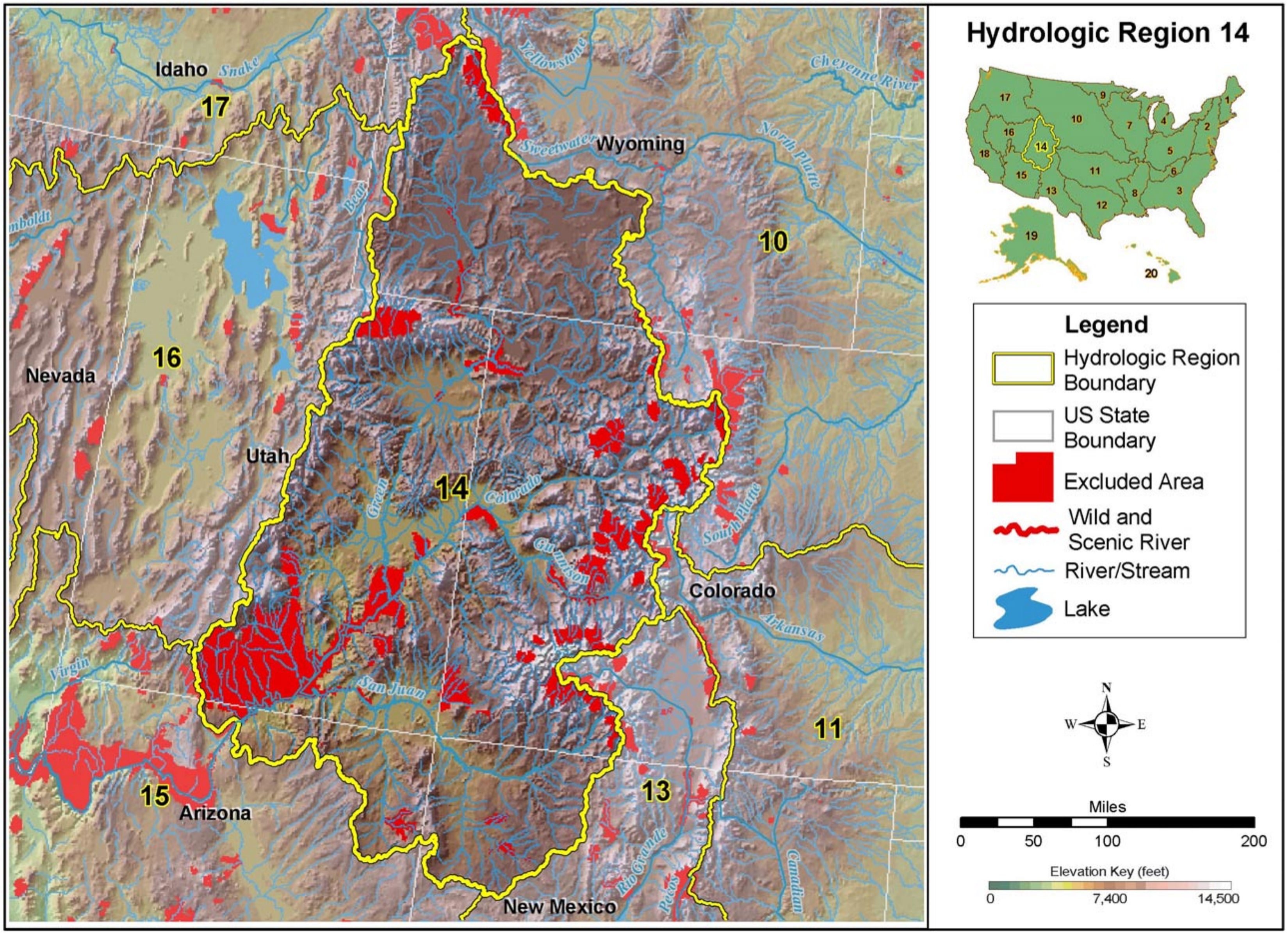


Figure A-66. Upper Colorado Region (HUC 14).

Table A-14. Summary of results of water energy resource assessment of the Upper Colorado Region (HUC 14).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**9,489**	**723**	**2,692**	**6,074**
TOTAL HIGH POWER	**6,934**	**717**	**2,155**	**4,062**
High Head/High Power	**5,664**	**717**	**1,857**	**3,090**
Low Head/High Power	**1,270**	**0**	**298**	**972**
TOTAL LOW POWER	**2,555**	**6**	**537**	**2,012**
High Head/Low Power	**1,876**	**6**	**468**	**1,402**
Low Head/Low Power	**679**	**0**	**69**	**610**
Conventional Turbine	198	0	10	188
Unconventional Systems	103	0	14	89
Microhydro	378	0	45	333

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

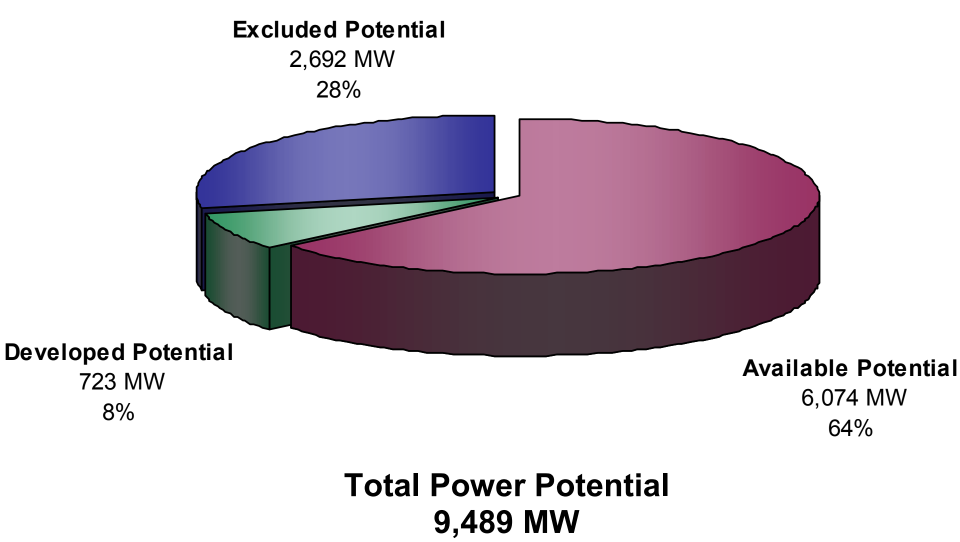


Figure A-67. Power category distribution of the total power potential (annual mean power) of water energy resources in the Upper Colorado Region (HUC 14).

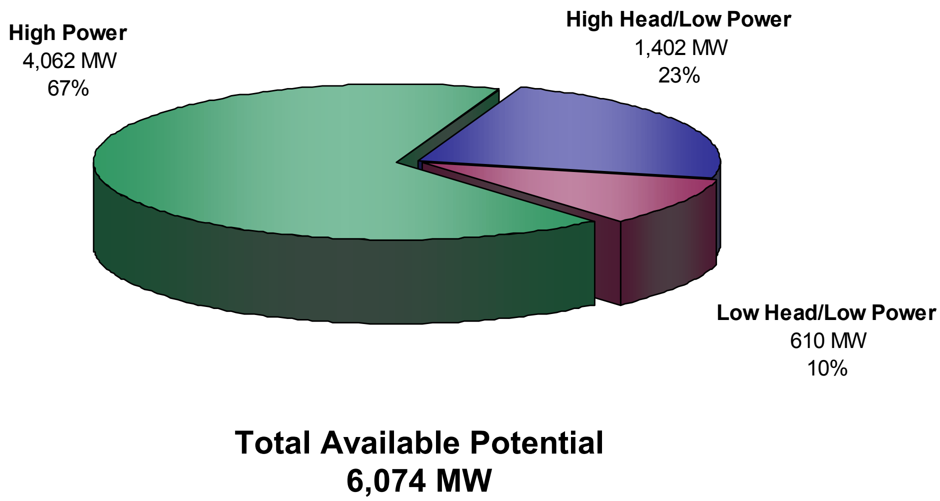


Figure A-68. Power class distribution of the available power potential (annual mean power) of water energy resources in the Upper Colorado Region (HUC 14).

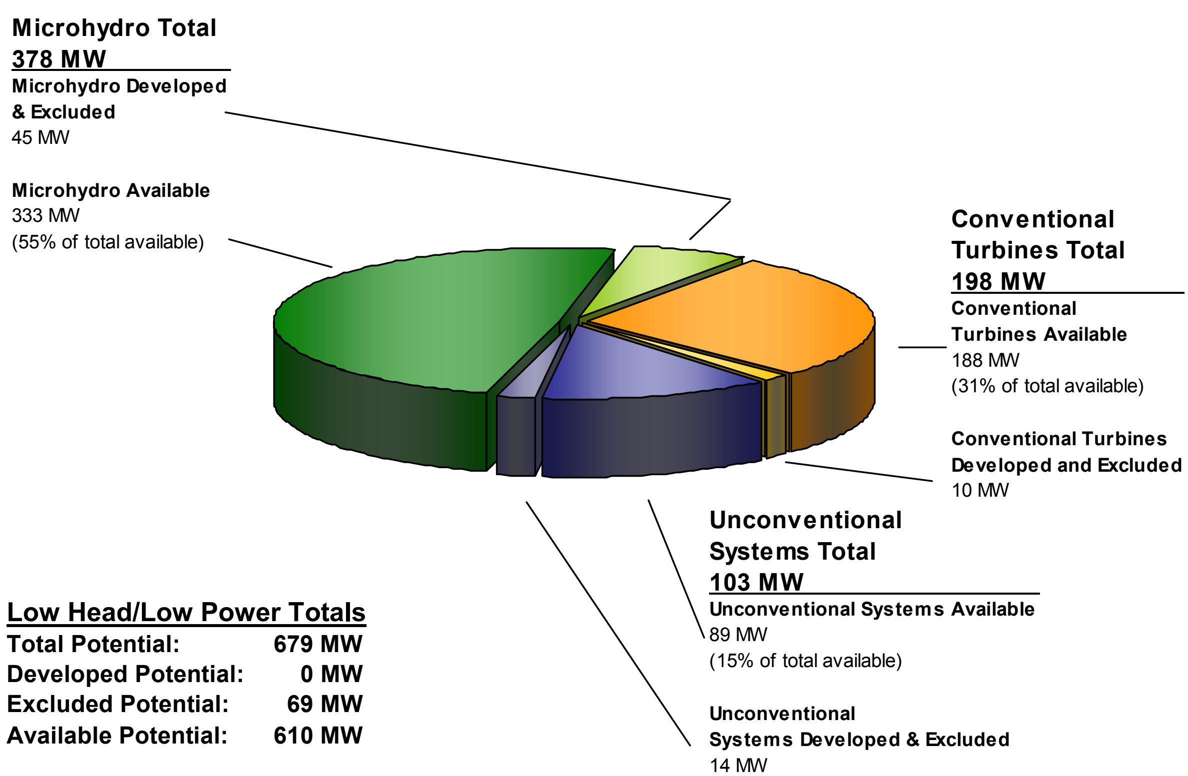


Figure A-69. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Upper Colorado Region (HUC 14) among three low head/low power hydropower technology classes.

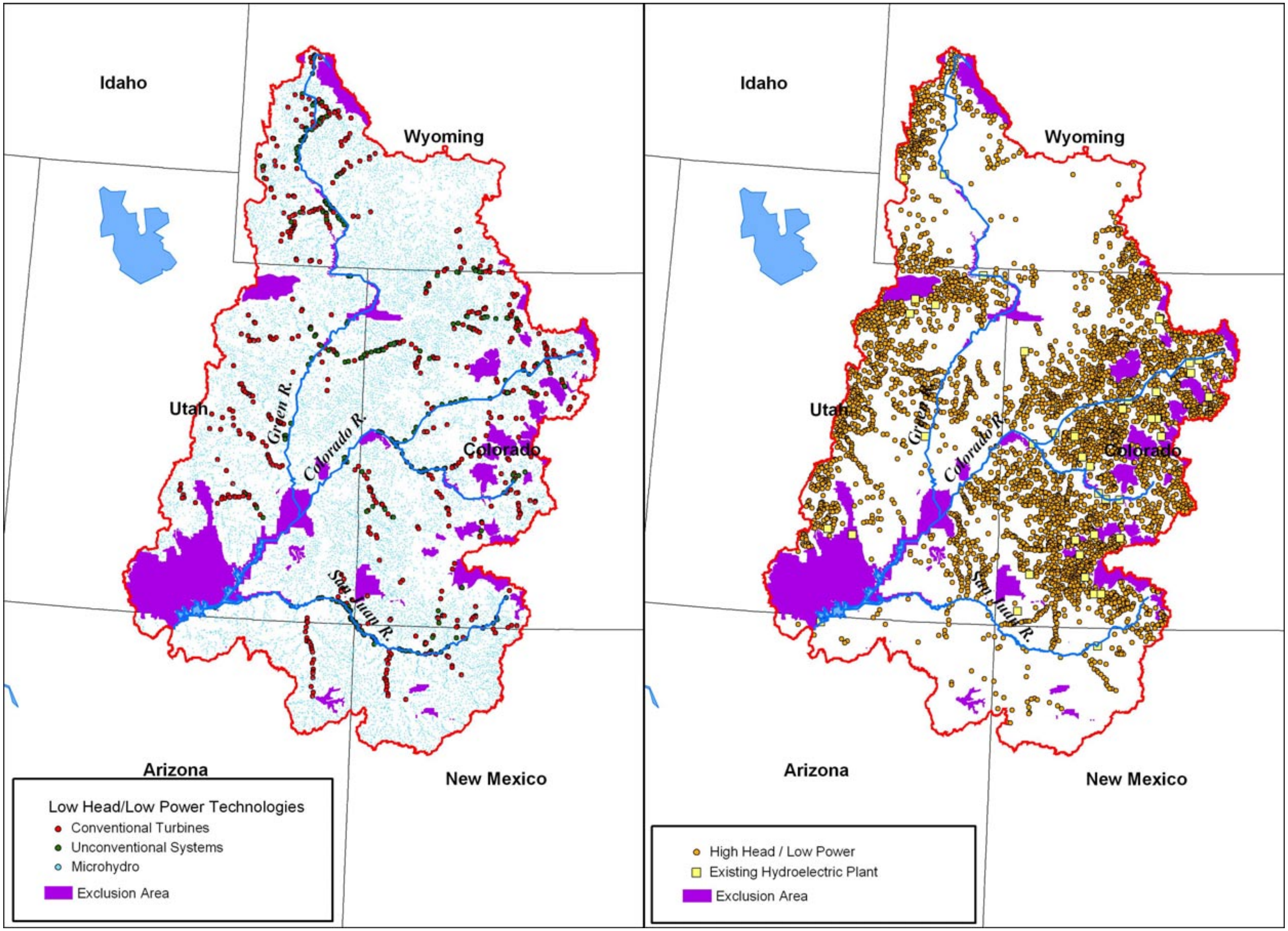


Figure A-70. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Upper Colorado Region (HUC 14).

A.15 Lower Colorado Region

A.15.1 Region Description

The topographic and hydrographic features of the Lower Colorado Region are shown in Figure A-71. The region is roughly coincident with the State of Arizona, and also includes small portions of California, Nevada, Utah, and New Mexico.

The Colorado River is the principal river in this region. Principal tributaries of the Colorado River include the Virgin River (southern Utah and Nevada) and the Salt and Gila Rivers (central and southern Arizona). The largest hydropower project in this region is Lake Mead on the Colorado River. Created in the 1930s by Hoover Dam, Lake Mead provides flood control, water supply, and hydropower to several western states. Further downstream, other dams on the Colorado River formed additional reservoirs such as Lake Havasu. These reservoirs provide water for desert agriculture and major metropolitan areas in southern California, southern Nevada, and Arizona. So much water is diverted from the Colorado River in this region that only a small trickle of water reaches its outlet in the Gulf of California.

Physiographically, the Lower Colorado Region consists primarily of the southern Colorado Plateau and the southern Basin and Range Province with a transition zone between the two. The Colorado Plateau is a regional highland that covers the northern part of the region in Utah and Arizona. Although relatively flat, the Colorado Plateau also includes many mesas and buttes. It is bisected by the Grand Canyon of the Colorado River (5,000 feet deep) as well as by canyons of tributary streams. Many of these spectacular natural features are preserved as national parks, monuments, or recreation areas. In general, the Colorado Plateau is cooler and wetter than surrounding areas because of its higher elevation. The highest areas receive sufficient precipitation to sustain extensive coniferous forests, including the largest stand of ponderosa pines in the world.

The Basin and Range Province is a north-south trending series of alternating mountain ranges and tectonic valleys extending from northern Nevada to southern Arizona. The Lower Colorado Region includes the southern portions of the Basin and Range Province, i.e., the portions in southern Nevada, southeastern California, and southern Arizona. The valleys are low-lying, while the mountains can reach several thousand feet above the valley floors. The climate is semi-arid to arid with intermittent streams and desert vegetation, including desert brush and cactus. The transition zone from the Colorado Plateau to the Basin and Range Province is a series of cliffs and slopes in northeastern Arizona known as the Mogillon Rim.

A.15.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

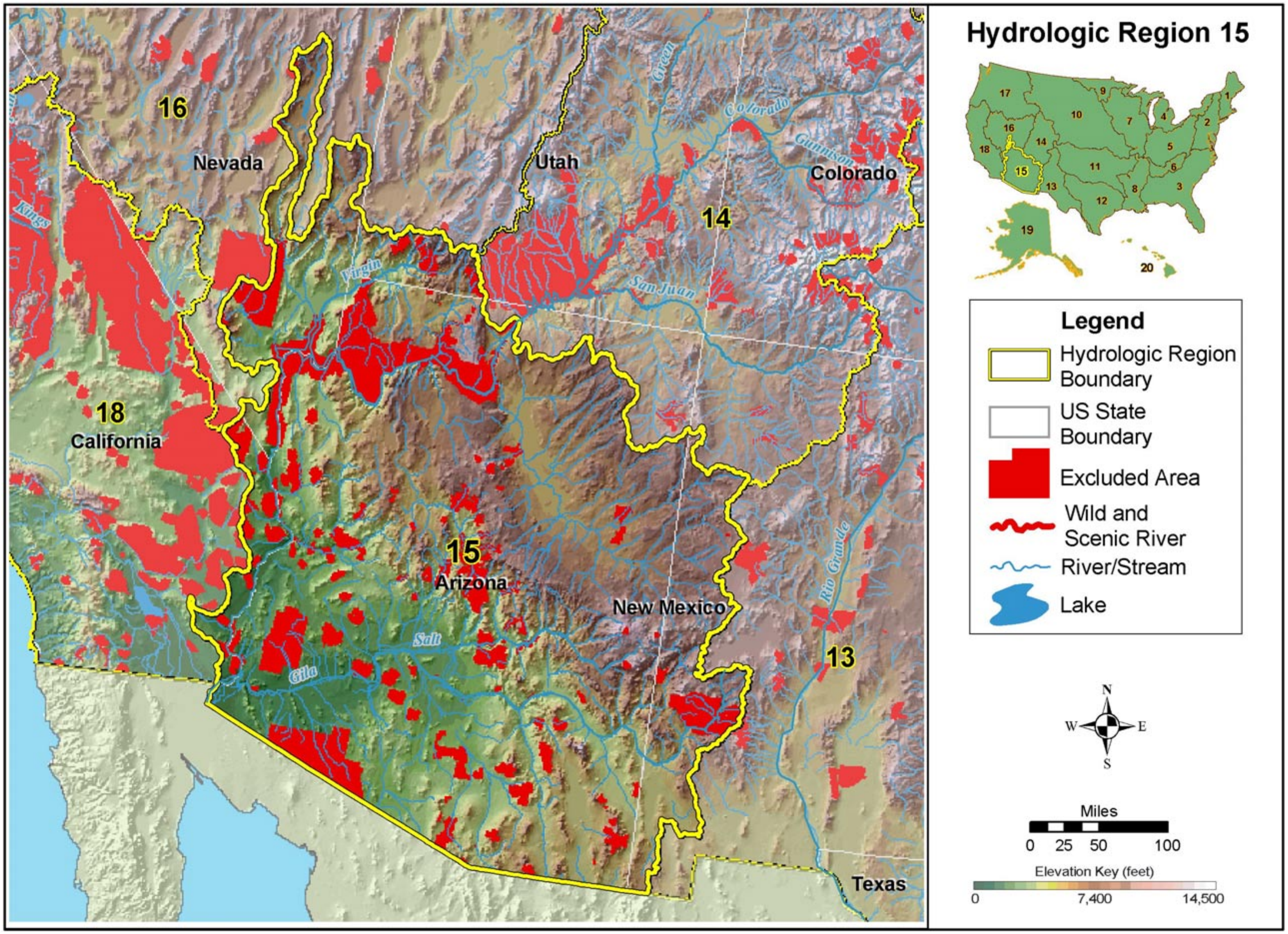


Figure A-71. Lower Colorado Region (HUC 15).

Table A-15. Summary of results of water energy resource assessment of the Lower Colorado Region (HUC 15).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**3,452**	**789**	**931**	**1,732**
TOTAL HIGH POWER	**1,935**	**785**	**588**	**562**
High Head/High Power	**1,273**	**785**	**53**	**435**
Low Head/High Power	**662**	**0**	**535**	**127**
TOTAL LOW POWER	**1,517**	**4**	**343**	**1,170**
High Head/Low Power	**849**	**4**	**238**	**607**
Low Head/Low Power	**668**	**0**	**105**	**563**
Conventional Turbine	193	0	22	171
Unconventional Systems	55	0	13	42
Microhydro	420	0	70	350

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

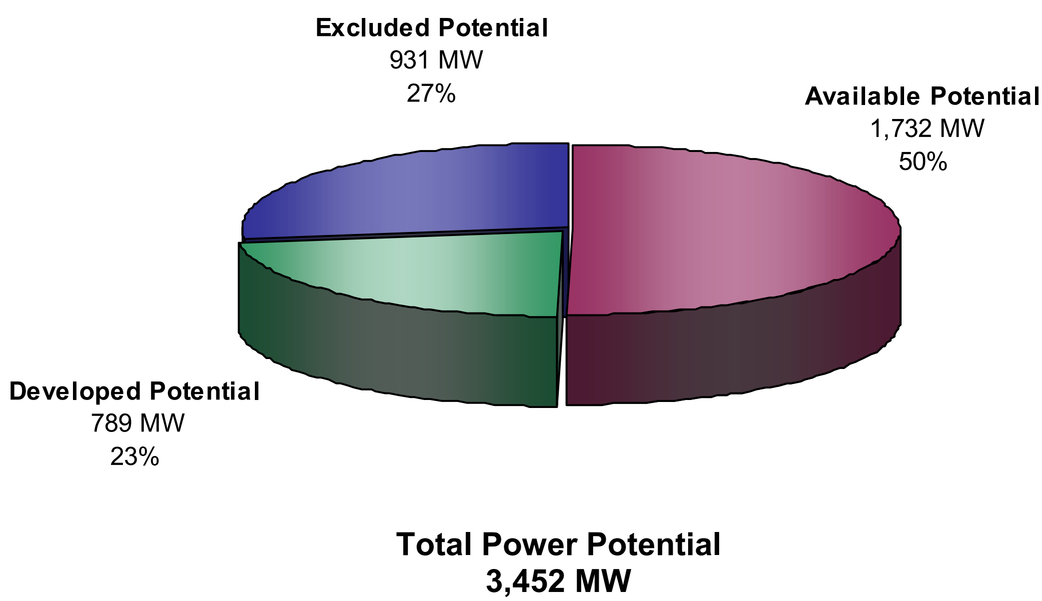


Figure A-72. Power category distribution of the total power potential (annual mean power) of water energy resources in the Lower Colorado Region (HUC 15).

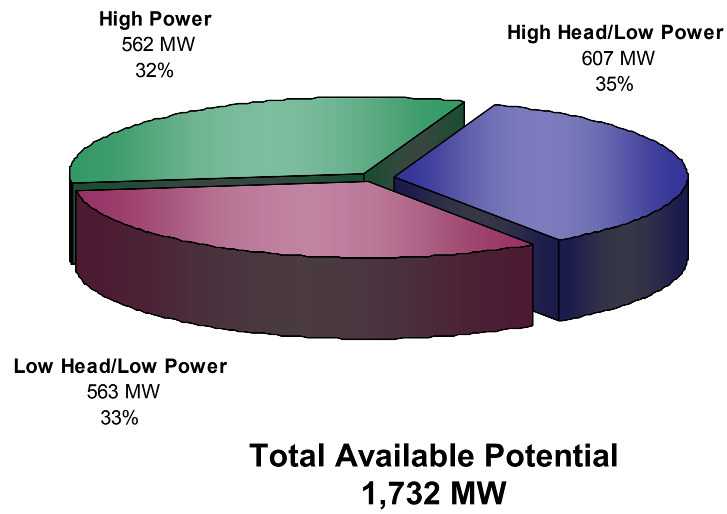


Figure A-73. Power class distribution of the available power potential (annual mean power) of water energy resources in the Lower Colorado Region (HUC 15).

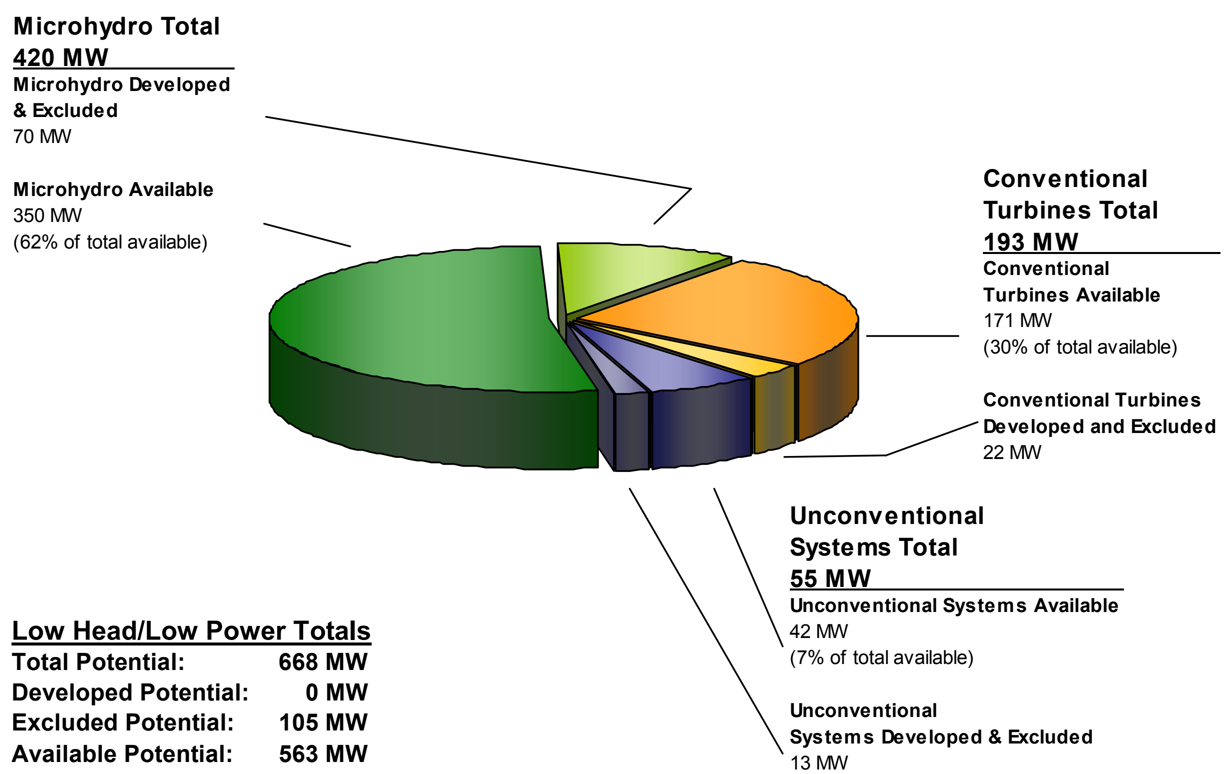


Figure A-74. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Lower Colorado Region (HUC 15) among three low head/low power hydropower technology classes.

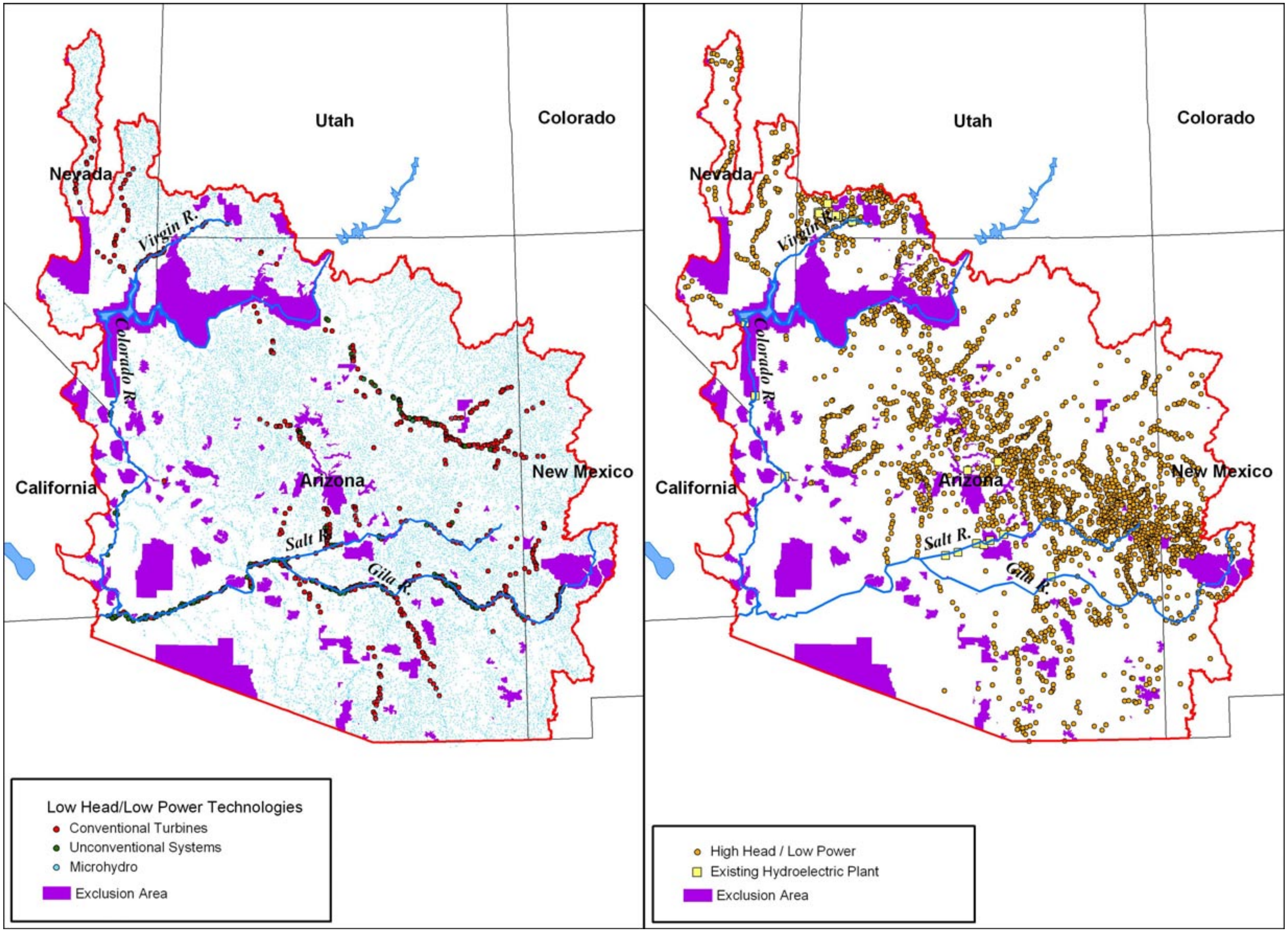


Figure A-75. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Lower Colorado Region (HUC 15).

A.16 Great Basin Region

A.16.1 Region Description

The topographic and hydrographic features of the Great Basin Region are shown in Figure A-76. The region roughly coincides with the State of Nevada and the western half of Utah. The region also includes small portions of California, Oregon, Idaho, and Wyoming.

The Great Basin is a semi-arid to arid region of interior drainage. The rivers and streams in this region have no outlet to the sea. Instead, they flow to alkali flats, mud flats, or saline lakes on the valley floors. Most of the Great Basin lies within the northern half of the Basin and Range Province, an alternating series of north-south trending mountain ranges and tectonic valleys. Valley floors range from 2,000 to 6,000 feet in elevation while mountain ranges are generally 7,000 to 9,000 feet in elevation, with some peaks exceeding 13,000 feet. The Great Basin is bounded on the west by the Sierra Nevada and nearby mountain ranges and on the east by the Wasatch Range and the Colorado Plateau. The Great Basin lies in the rain shadow of the Sierra Nevada, which captures most of the moisture from Pacific storms. Because of the dry climate, perennial rivers and streams are found only near major mountain ranges. The principal rivers are the Truckee, Carson, and Walker Rivers, which originate in the Sierra Nevada; the Bear River, which is fed by streams in the mountains of Utah and Wyoming; and the Humboldt River of northern Nevada. Mountain ranges, such as the Sierra Nevada and the Wasatch Range, are the only areas of significant precipitation.

Lake Tahoe, the largest mountain lake in the conterminous United States, lies astride the California-Nevada state line near the western edge of the Great Basin. It is known for its depth, clarity, and scenic beauty. Most other lakes in the region are saline or brackish. The Great Salt Lake is a shallow, extensive saltwater lake covering thousands of square miles of desert flatlands northwest of Salt Lake City, Utah. By area, it is the largest lake in the western United States, but its actual size depends on the amount of precipitation falling in the nearby Wasatch Range. If the lake level rises or falls a few feet, the lakeshore can move several miles outward or inward due to the flatness of the valley floor it occupies.

The Great Basin is mostly dry, with cold winters and short, hot summers in the north. In the south, winters are shorter and milder, with long, hot summers.

A.16.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

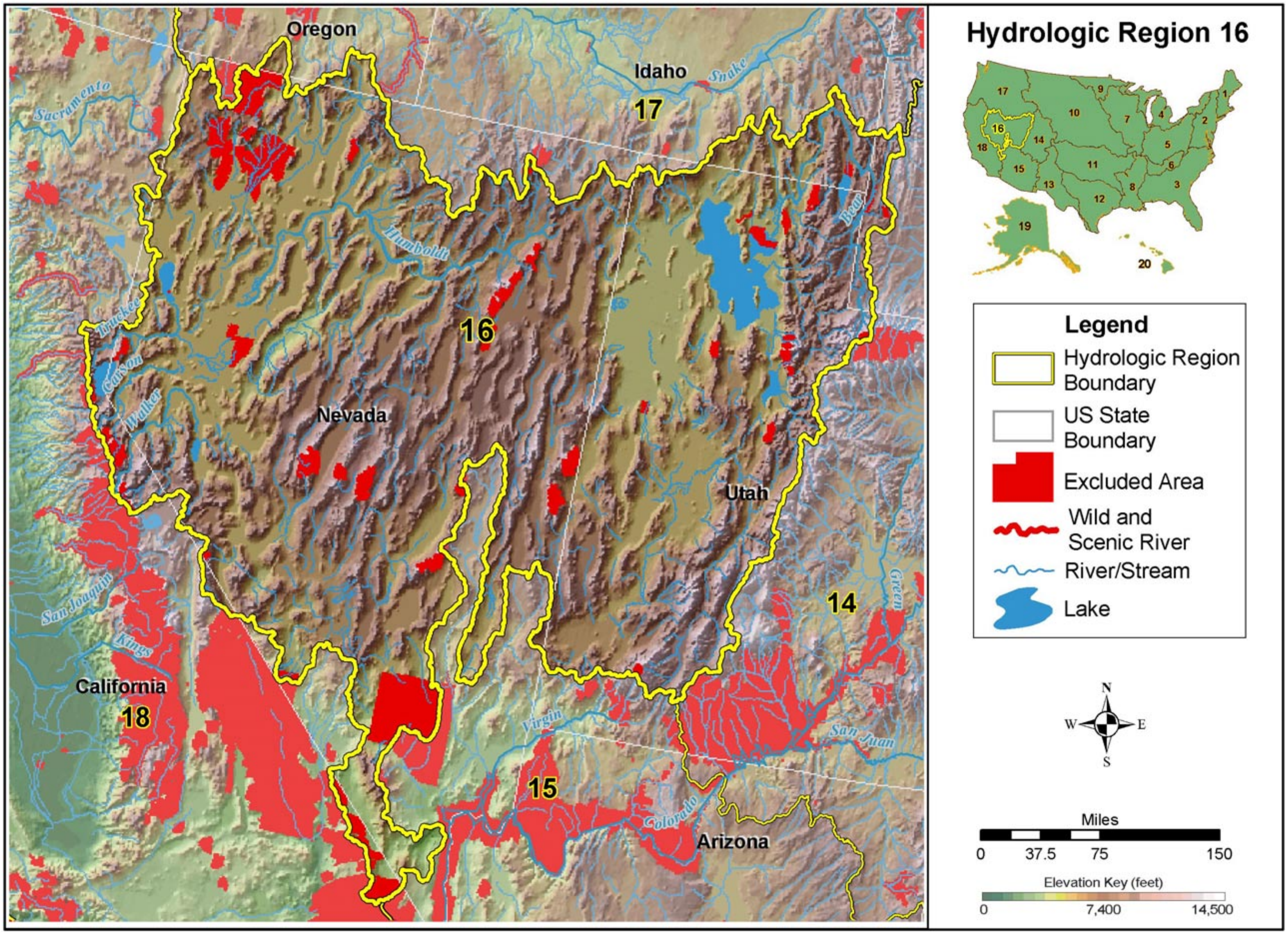


Figure A-76. Great Basin Region (HUC 16).

Table A-16. Summary of results of water energy resource assessment of the Great Basin Region (HUC 16).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**3,043**	**97**	**452**	**2,494**
TOTAL HIGH POWER	**1,303**	**80**	**281**	**942**
High Head/High Power	**1,283**	**80**	**280**	**923**
Low Head/High Power	**20**	**0**	**1**	**19**
TOTAL LOW POWER	**1,740**	**17**	**171**	**1,552**
High Head/Low Power	**1,133**	**15**	**145**	**973**
Low Head/Low Power	**607**	**2**	**26**	**579**
Conventional Turbine	124	1	0	123
Unconventional Systems	25	0	1	24
Microhydro	458	1	25	432

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

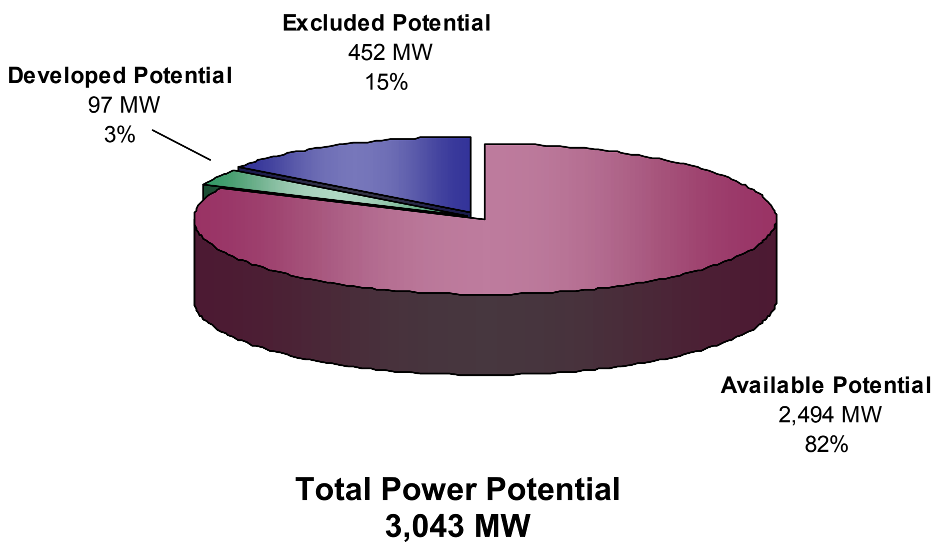


Figure A-77. Power category distribution of the total power potential (annual mean power) of water energy resources in the Great Basin Region (HUC 16).

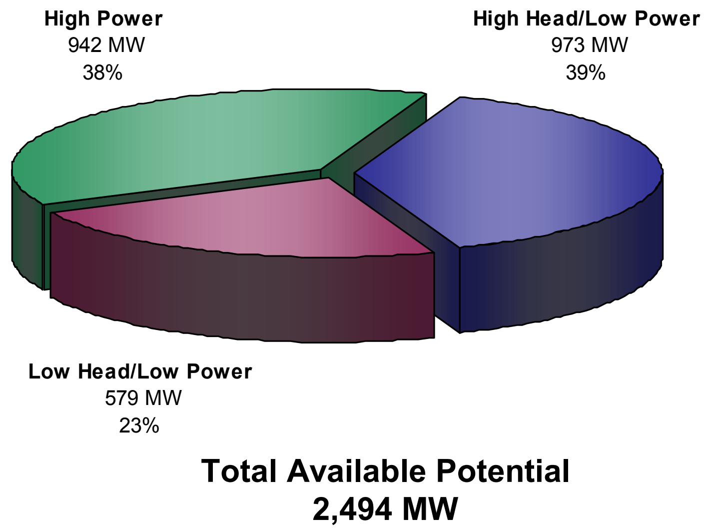


Figure A-78. Power class distribution of the available power potential (annual mean power) of water energy resources in the Great Basin Region (HUC 16).

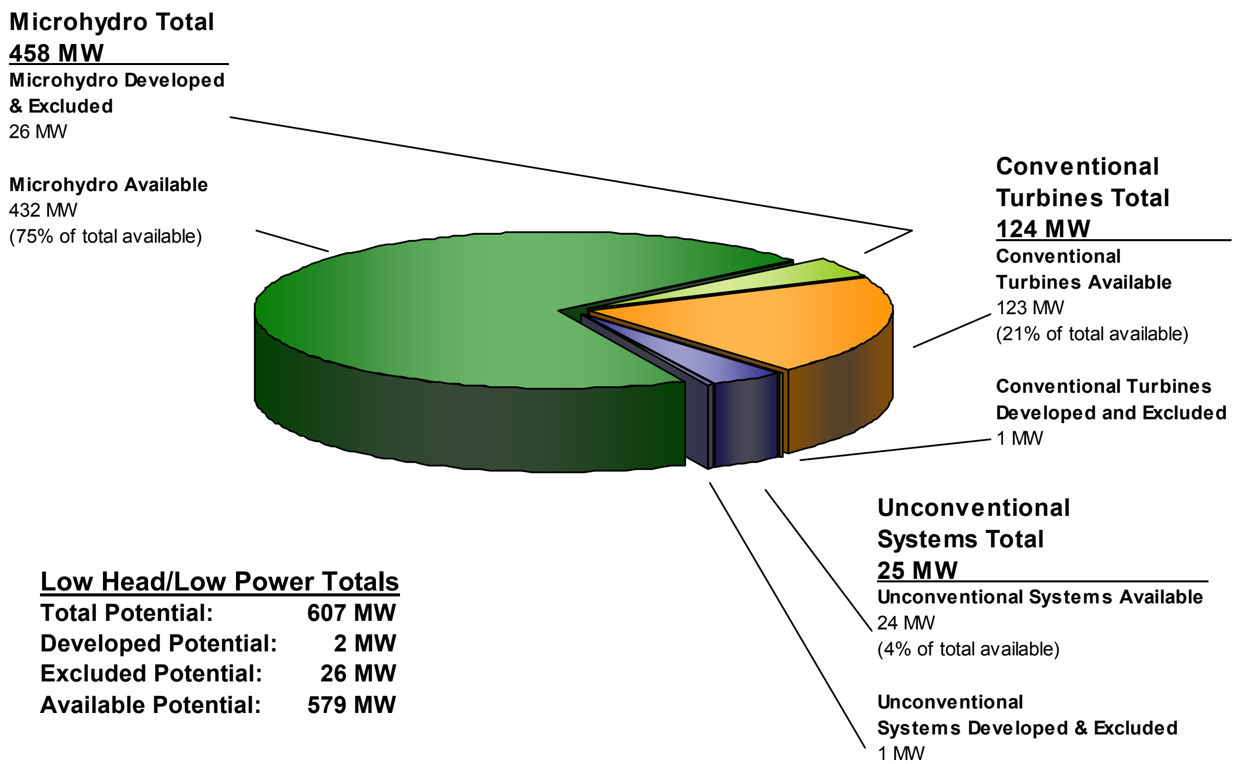


Figure A-79. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Great Basin Region (HUC 16) among three low head/low power hydropower technology classes.

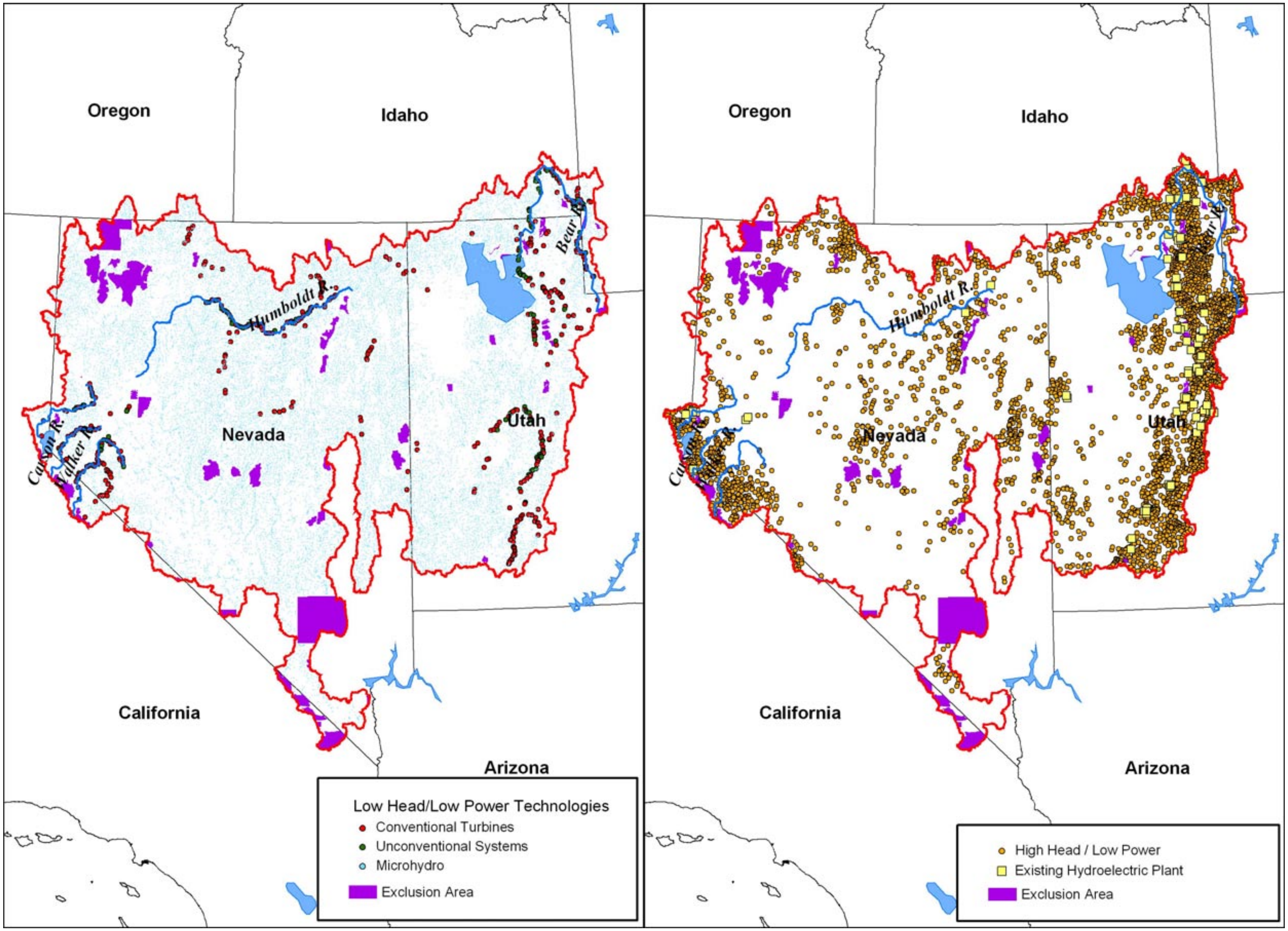


Figure A-80. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Great Basin Region (HUC 16).

A.17 Pacific Northwest Region

A.17.1 Region Description

The topographic and hydrographic features of the Pacific Northwest Region are shown in Figure A-81. The region covers the entire State of Washington, most of Oregon and Idaho, and part of western Montana. The region also includes small parts of California, Nevada, Utah, and Wyoming. Geography and climate vary significantly within the Pacific Northwest Region. Land elevations range from sea level to over 14,000 feet. The region includes high mountains, extensive plains, and deep canyons. Climatic zones range from rain forests in the west to high deserts and steppes in the central interior.

Two major mountain systems are found in the western part of the region: the Coast Range and the volcanic mountains of the Cascade Range. Oregon's Willamette Valley and Washington's Puget Sound Lowlands separate these two mountain systems. The climate of these areas are relatively wet because of their exposure to Pacific storm systems. The Columbia Plateau, east of the Cascade Range in eastern Washington and Oregon, consists primarily of extensive basalt plains dissected in some places by deep canyons. The basalt flows also extend completely across southern Idaho forming the Snake River Plain. The Rocky Mountains cover central and northern Idaho, western Montana, and westernmost Wyoming. Basin and range features (alternating mountains and valleys) occur along the interior southern border of the region in southernmost Idaho, northern Nevada, northern Utah, and northeastern California. Arid climates are dominate in the Columbia Plateau, Snake River Plain, and basin and range regions.

Two major rivers drain most of this region, the Columbia River and its largest tributary, the Snake River. The Columbia River originates in the Canadian Rockies, crossing from Canada into northern Washington. It traverses southward across the Columbia Plateau of central Washington, then bends westward to form part of the Oregon-Washington state line. During its westward flow to the Pacific Ocean, it crosses both the Cascade Ranges and the Coast Ranges. Numerous large hydropower projects, including the Grand Coulee Dam occur along the Columbia River.

The Snake River originates in western Wyoming near Yellowstone National Park. It traverses the entire length of southern Idaho along the Snake River Plain, then turns northward into Hells Canyon. The Snake River joins the Columbia in south-central Washington. Other tributaries of the Columbia include the Willamette River in western Oregon, the Flathead River and Clarks Fork in western Montana, and the Pend Oreille River in northern Idaho and Washington.

A.17.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

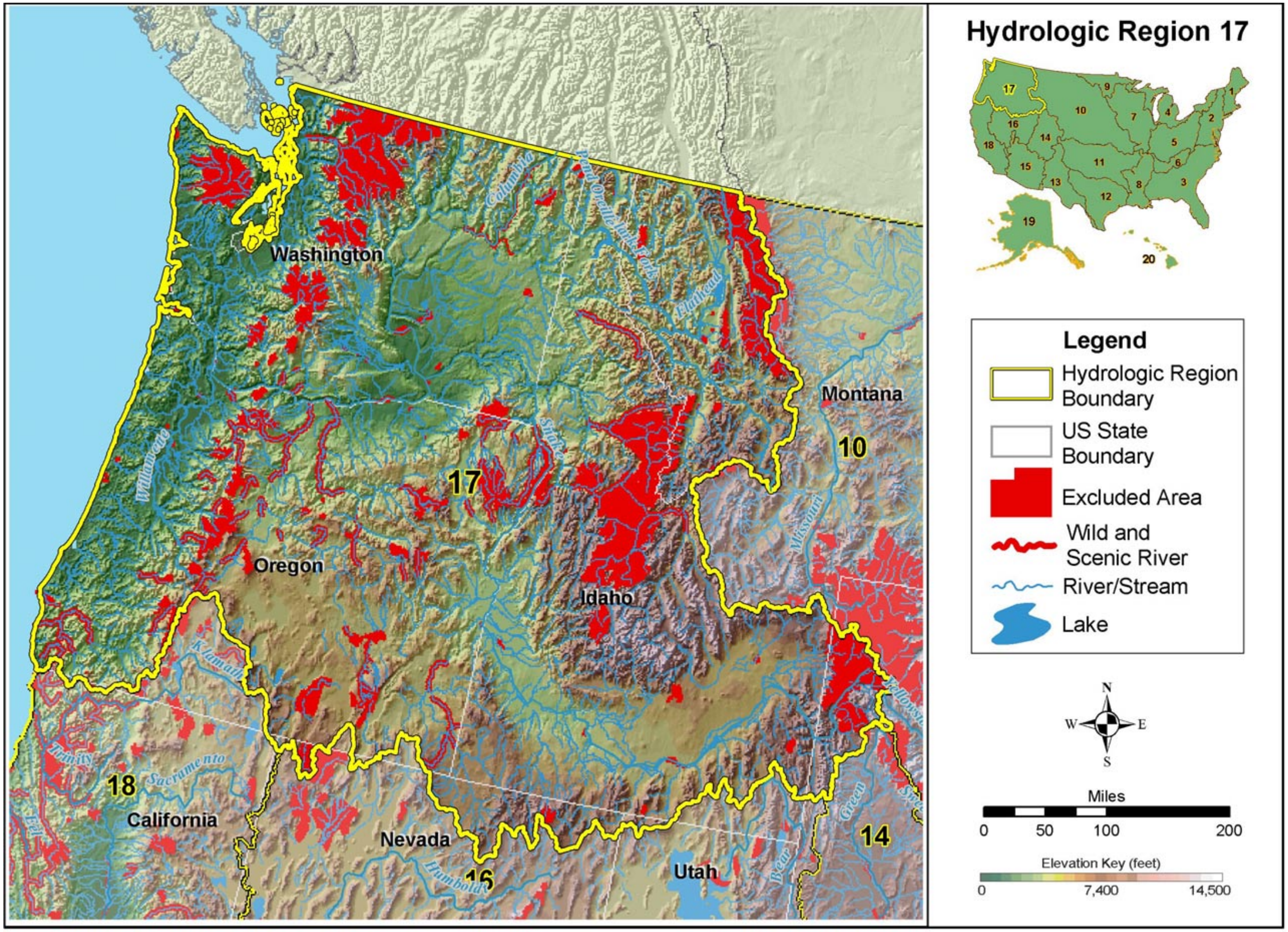


Figure A-81. Pacific Northwest Region (HUC 17).

Table A-17. Summary of results of water energy resource assessment of the Pacific Northwest Region (HUC 17).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**76,440**	**16,644**	**20,009**	**39,787**
TOTAL HIGH POWER	**66,654**	**16,600**	**18,363**	**31,691**
High Head/High Power	**56,976**	**16,526**	**15,409**	**25,041**
Low Head/High Power	**9,678**	**74**	**2,954**	**6,650**
TOTAL LOW POWER	**9,786**	**44**	**1,646**	**8,096**
High Head/Low Power	**7,785**	**39**	**1,456**	**6,290**
Low Head/Low Power	**2,001**	**5**	**190**	**1,806**
Conventional Turbine	698	3	69	626
Unconventional Systems	312	0	58	254
Microhydro	991	2	63	926

a. No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

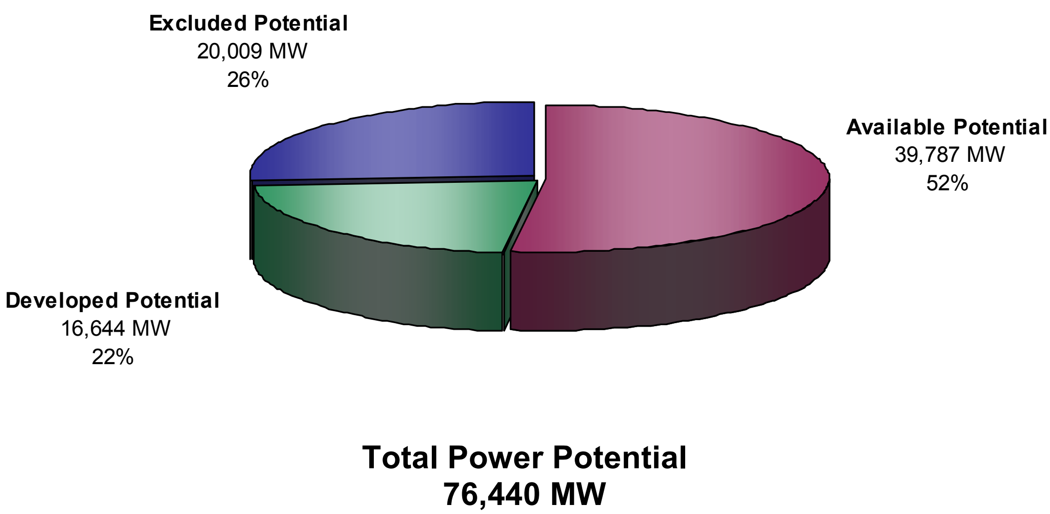


Figure A-82. Power category distribution of the total power potential (annual mean power) of water energy resources in the Pacific Northwest Region (HUC 17).

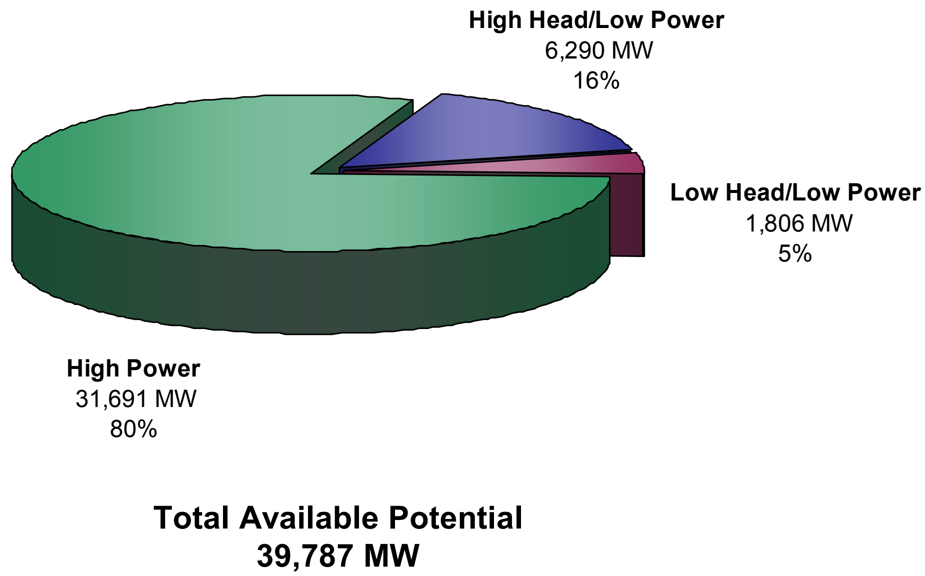


Figure A-83. Power class distribution of the available power potential (annual mean power) of water energy resources in the Pacific Northwest Region (HUC 17).

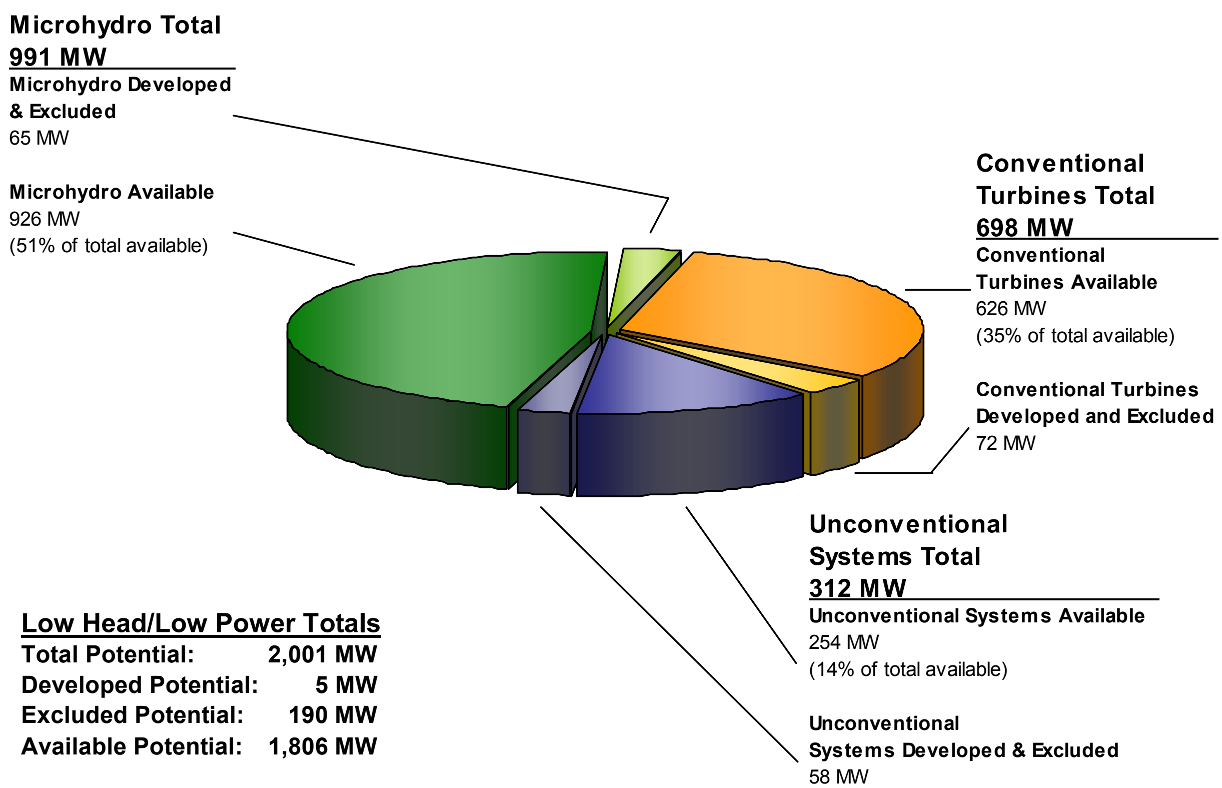


Figure A-84. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Pacific Northwest Region (HUC 17) among three low head/low power hydropower technology classes.

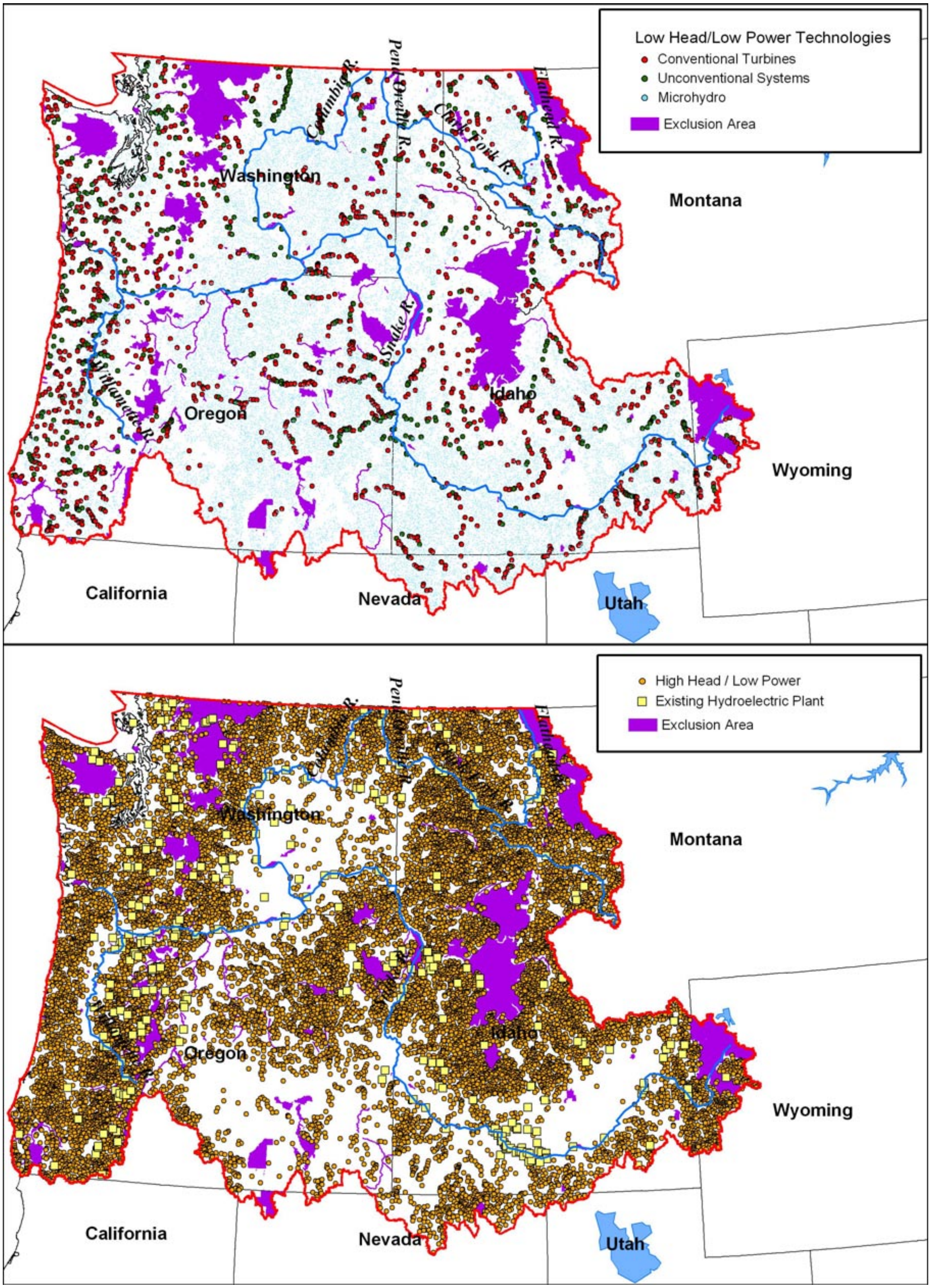


Figure A-85. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Pacific Northwest Region (HUC 17).

A.18 California Region

A.18.1 Region Description

The topographic and hydrographic features of the California Region are shown in Figure A-86. The region is roughly coincident with the State of California, but includes small parts of Nevada and Oregon. The California Region contains a wide variety of landscapes, from damp coastal forests to empty desert waste. It contains some of the largest urban areas in the nation as well as some of the most desolate uninhabited areas. Mount Whitney, the highest point in the conterminous United States (14,496 feet) is only 85 miles from Death Valley, the lowest point in North America (280 feet below sea level).

The region consists of a steep rugged coastline directly bordered by the Coast Ranges, a series of mountain ranges that run nearly continuously from the Mexican border to the Oregon state line. These mountains are mostly 3,000 to 6,000 feet in elevation, but reach heights exceeding 11,000 feet in southern California. Coastal plains are minimal to absent, except for the moderate-sized plain underlying the Los Angeles metropolitan area. Natural bays and harbors are generally lacking, with the notable exceptions of San Diego Bay and San Francisco Bay. The Great Central Valley lies inland from the Coast Ranges, extending 400 miles from north to south in central and northern California. Beyond the Central Valley rises the Sierra Nevada, a continuous 400-mile long fault block range that rises to heights exceeding 14,000 feet. In southern California, desert landscapes dominate the areas behind the Coast Ranges. These include desert mountain ranges alternating with deep valleys or alluvial plains.

The high mountains consist of extensive coniferous forests in the north to mixed forest and shrubland in the south. The lowest desert valleys contain dry salt and alkali flats with extremely hot temperatures in the summer (exceeding 120°F in Death Valley). The principal population centers are near the natural harbors or coastal plains, namely the San Francisco, Los Angeles, and San Diego metropolitan areas. Other major cities such as Sacramento and Fresno are in the agricultural heartland of the Central Valley. All these cities have extended suburbs and contain many of the 30 million inhabitants of the region. By contrast, much of the inland desert is sparsely populated.

The principal rivers include the Sacramento and San Joaquin Rivers, whose tributary streams (including the Kings River) drain the western slopes of the Sierra Nevada. Other rivers include the Klamath, Trinity, and Eel Rivers, which flow from the northern Coast Ranges directly into the Pacific Ocean. In general, the rivers are not navigable. However, deep ship channels extend from San Francisco Bay into the Central Valley to the inland ports of Sacramento and Stockton.

Most of the California Region has a Mediterranean climate with cool, wet winters and long, dry summers with little or no rainfall between May and November. The domestic and agricultural water supply for the region's 30 million inhabitants comes in great part from winter Pacific storms originating in the Gulf of Alaska. The storms drop their moisture on the Coast Ranges and Sierra Nevada as rainfall and snowfall, respectively. Most of this precipitation is stored as winter snowpack in the Sierra, which is captured in reservoirs constructed on most of the streams draining the slopes of the Sierra. These reservoirs provide water storage, flood control, recreation, and hydropower for the region. The water stored in these reservoirs is used both for agriculture and domestic use. The major population centers near the coast (San Francisco, Los Angeles, and San Diego) import mountain stream water from hundreds of miles away using a vast network of canals and aqueducts. The aqueducts serving southern California import water from the Sierra Nevada and the Colorado River, crossing desert and mountain ranges to supply a large population.

A.18.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class

- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)

- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)

- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes

- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

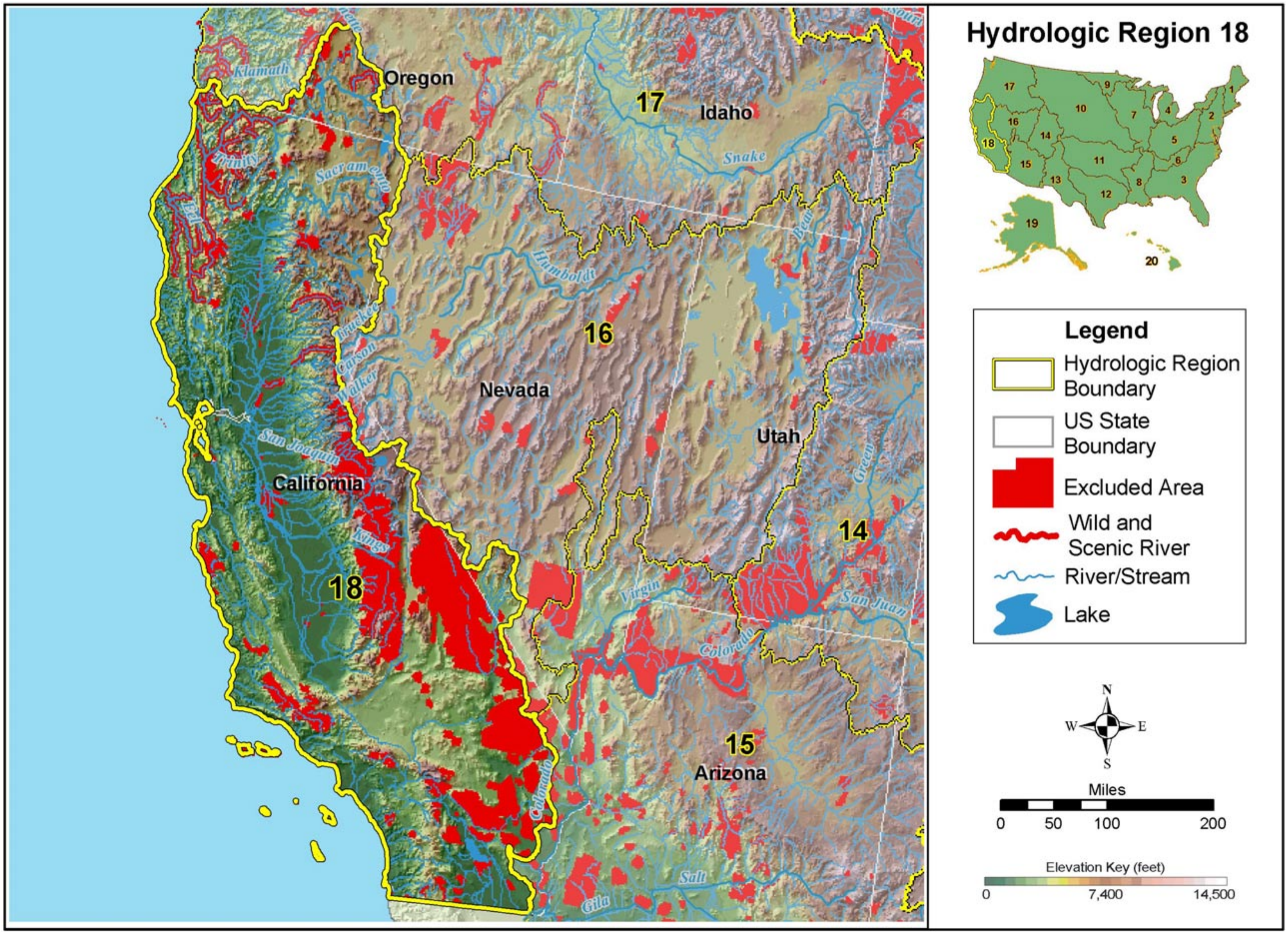


Figure A-86. California Region (HUC 18).

Table A-18. Summary of results of water energy resource assessment of the California Region (HUC 18).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**26,953**	**4,668**	**12,042**	**10,243**
TOTAL HIGH POWER	**23,192**	**4,611**	**10,898**	**7,683**
High Head/High Power	**21,669**	**4,589**	**9,865**	**7,215**
Low Head/High Power	**1,523**	**22**	**1,033**	**468**
TOTAL LOW POWER	**3,761**	**57**	**1,144**	**2,560**
High Head/Low Power	**2,946**	**48**	**985**	**1,913**
Low Head/Low Power	**815**	**9**	**159**	**647**
Conventional Turbine	239	5	39	195
Unconventional Systems	103	1	25	77
Microhydro	473	3	95	375

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

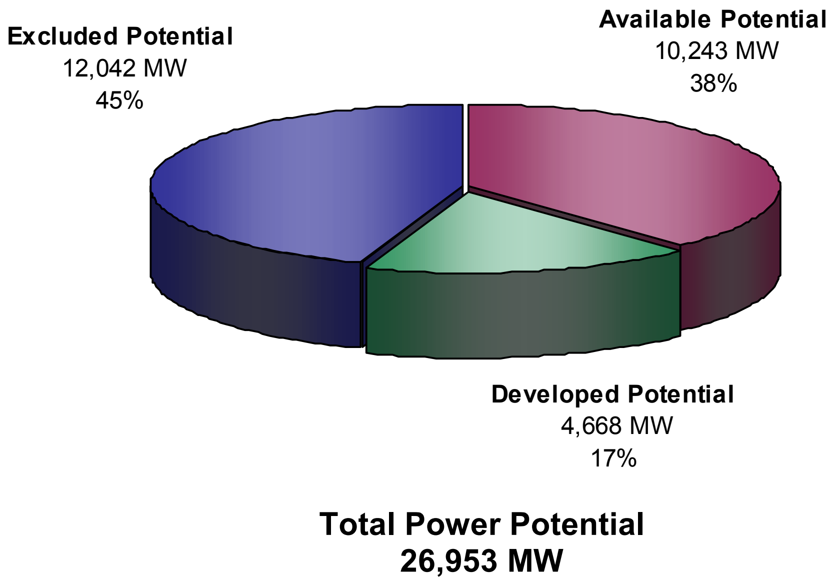


Figure A-87. Power category distribution of the total power potential (annual mean power) of water energy resources in the California Region (HUC 18).

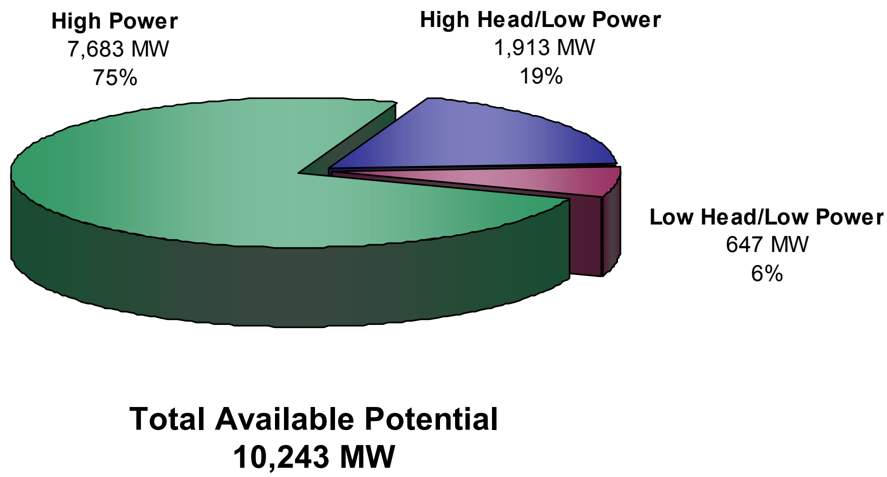


Figure A-88. Power class distribution of the available power potential (annual mean power) of water energy resources in the California Region (HUC 18).

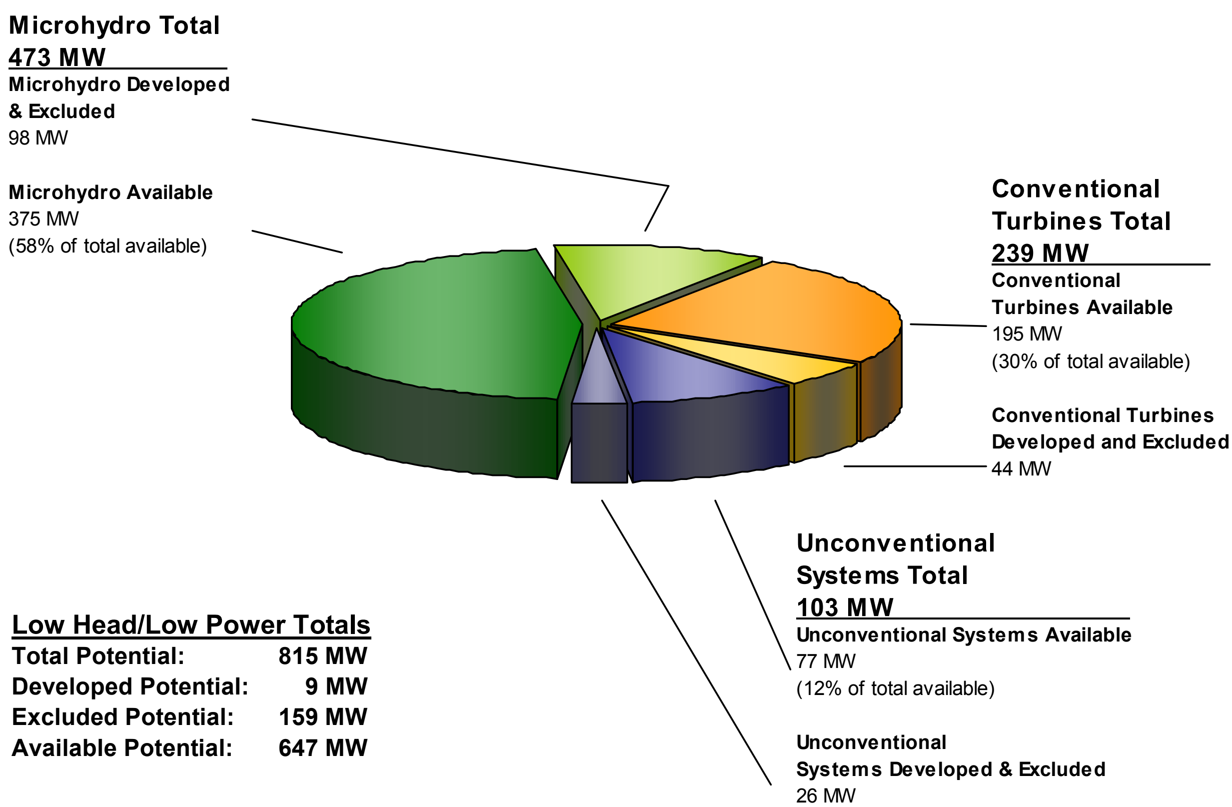


Figure A-89. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the California Region (HUC 18) among three low head/low power hydropower technology classes.

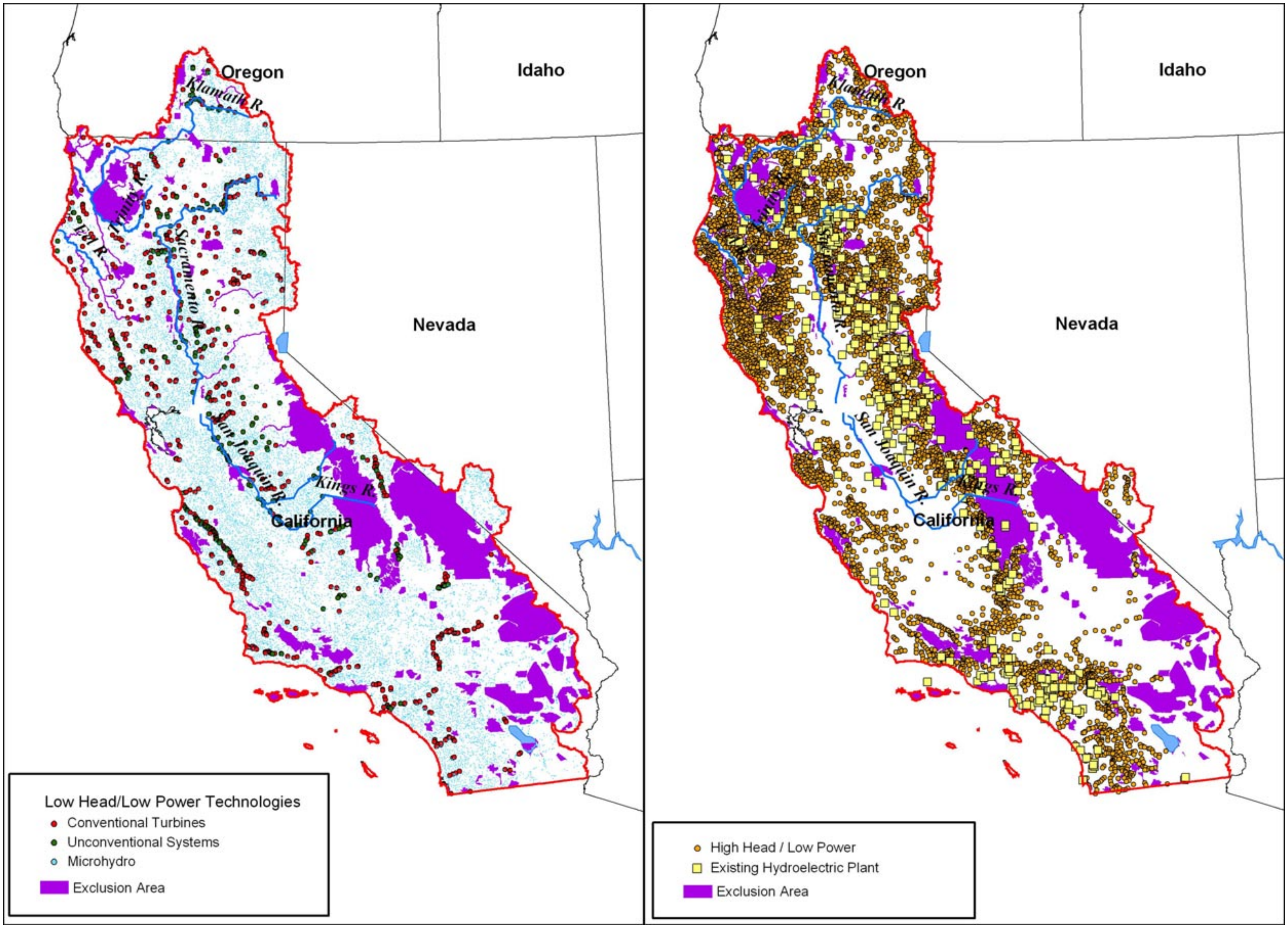


Figure A-90. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the California Region (HUC 18).

A.19 Alaska Region

A.19.1 Region Description

The topographic and hydrographic features of the Alaska Region are shown in Figure 91. The region is coincident with the State of Alaska, the largest, least populated, and northernmost state in the U.S. Elevations in Alaska range from sea level to over 20,000 feet.

Natural resources in Alaska include oil, timber, minerals, fishing, and wildlife. Hydrographic features include numerous rivers, lakes, and glaciers. Most rivers are found in the unglaciated portions of southern Alaska. Many rivers are subject to intense seasonal flooding due to rapid melting of snow and ice during late spring and early summer. Fewer rivers are found in the northern portion of the state because of the arid climate and nearly permanently frozen landscape. Approximately one-third of the state lies north of the Arctic Circle.

Alaska contains several distinct physiographic, climatic and hydrographic regions. The southeast panhandle is an irregular mountain coastline dissected by numerous inlets and channels. The climate is wet. Dense coniferous forests cover the lower elevations while glaciers originate at higher elevations. Glacial landscapes dominate the area north of the panhandle, where the rugged and inaccessible St. Elias and Wrangell mountain ranges reach elevations exceeding 18,000 feet. Abundant moisture from the Pacific Ocean accumulates as snow and ice on these high mountains to produce the world's largest glaciated area outside of Australia and Greenland.

The southern coastal area, composed of offshore islands, inlets, mountains, and valleys has a more temperate climate because of a warm ocean current originating near Japan. The mountains in this area are lower and less rugged. The intervening lower valleys are suitable for agriculture. The Susitina River is the principal river found in this area. Most of Alaska's population, including Anchorage, the state's largest city, is found in this area.

The Alaska Peninsula and the Aleutian Islands, a volcanic island chain, form the southwest panhandle of the state. The climate is stormy, with intense winds and thick fog. The volcanoes in this region, as well as those along the entire southern coast of Alaska, lie in the "Rim of Fire," a geologically active belt running along the margins of the Pacific Ocean. The entire southern coastline of Alaska is subject to major geologic hazards, including earthquake, volcanic eruption, and tsunami.

The Alaska Range, the highest mountain range in the state, is found north of the coastal belt in the southern interior of mainland Alaska. Mt McKinley, also known as Denali, at 20,320 feet, is the highest point in North America. North of the Alaska Range, a broad east-west extent of low-lying landscape of tablelands, plains, and rivers reach across the interior of Alaska from the Canadian border to the Bering Sea. Several large rivers traverse this lowland, including the Yukon River as well as the Koskukwim, Koyukuk, and Porcupine Rivers. Many of these rivers are braided, as is typical with streams draining meltwater from snow and glacial ice.

North of these lowlands, the Brooks Range, an east-west trending mountain range, extends nearly across the entire state. The climate is semi-arid, with relatively few glaciers. Tundra and permafrost are found at lower elevations.

North of the Brooks Range, the land gradually slopes downward to a coastal lowland known as the North Slope. The North Slope is a cold, arid and treeless plain bordering the Arctic Ocean. The ground is frozen for most of the year, as is the seawater along the coast. The Colville River drains the central and western portions of this area during the brief and cool summer season. The North Slope contains productive oil fields as well as the Arctic National Wildlife Refuge. The Alaska Pipeline, a major oil pipeline, originates at Prudhoe Bay on the North Slope and extends southward across the state to a supertanker terminal on the south coast.

A.19.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class

- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)

- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)

- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes

- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

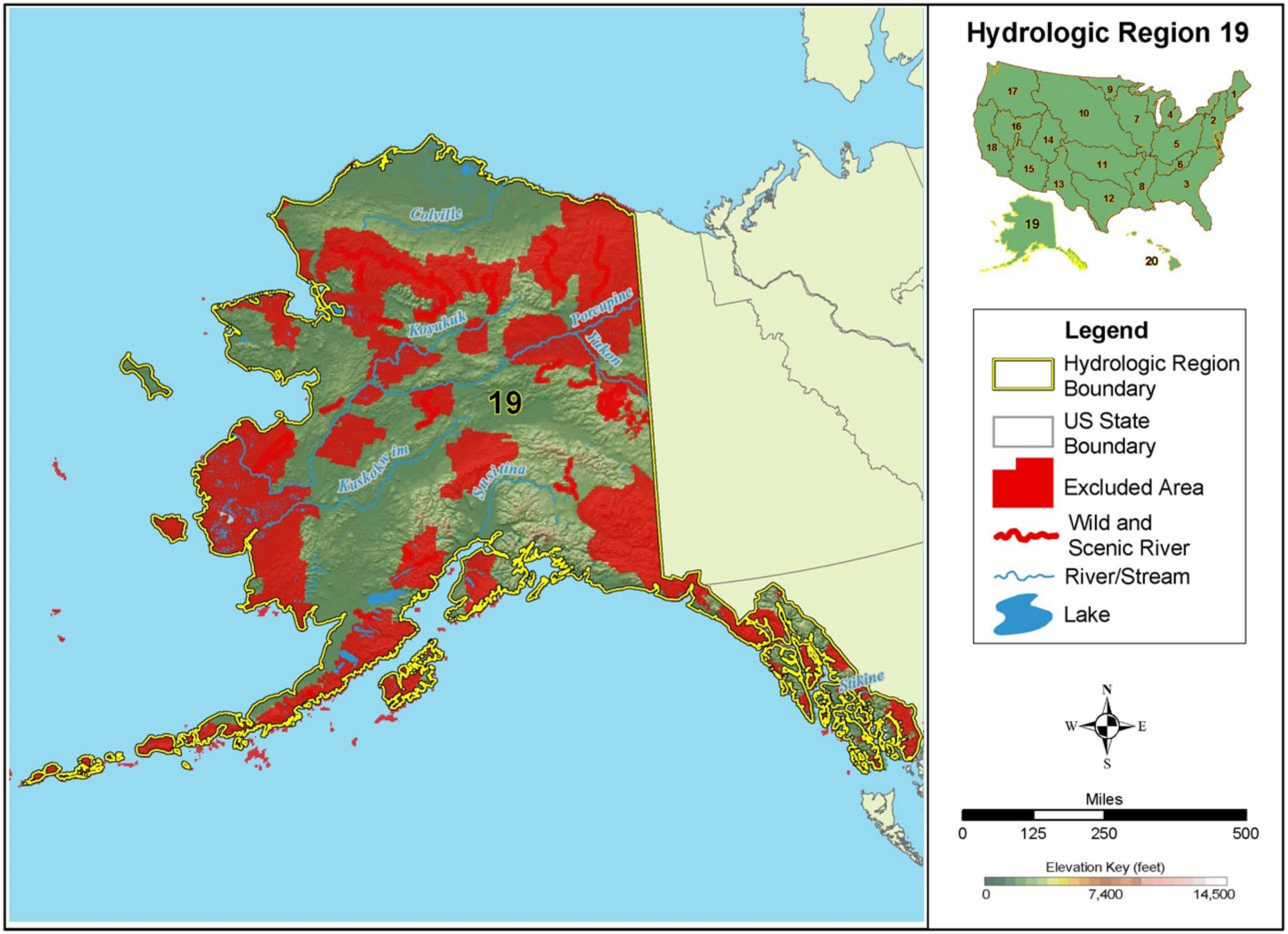


Figure A-91. Alaska Region (HUC 19).

Table A-19. Summary of results of water energy resource assessment of the Alaska Region (HUC 19).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**87,028**	**171**	**42,429**	**44,428**
TOTAL HIGH POWER	**72,632**	**167**	**36,225**	**36,240**
High Head/High Power	**45,782**	**167**	**22,246**	**23,369**
Low Head/High Power	**26,850**	**0**	**13,979**	**12,871**
TOTAL LOW POWER	**14,396**	**4**	**6,204**	**8,188**
High Head/Low Power	**10,243**	**4**	**4,667**	**5,572**
Low Head/Low Power	**4,153**	**0**	**1,537**	**2,616**
Conventional Turbine	1,418	0	521	897
Unconventional Settings	683	0	274	409
Microhydro	2,052	0	742	1,310

a. No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

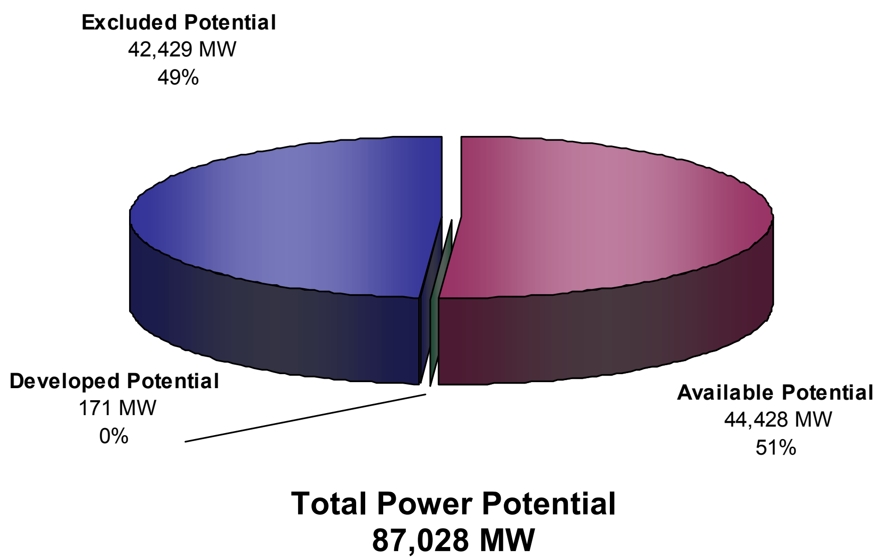


Figure A-92. Power category distribution of the total power potential (annual mean power) of water energy resources in the Alaska Region (HUC 19).

Alaska (HUC 19)

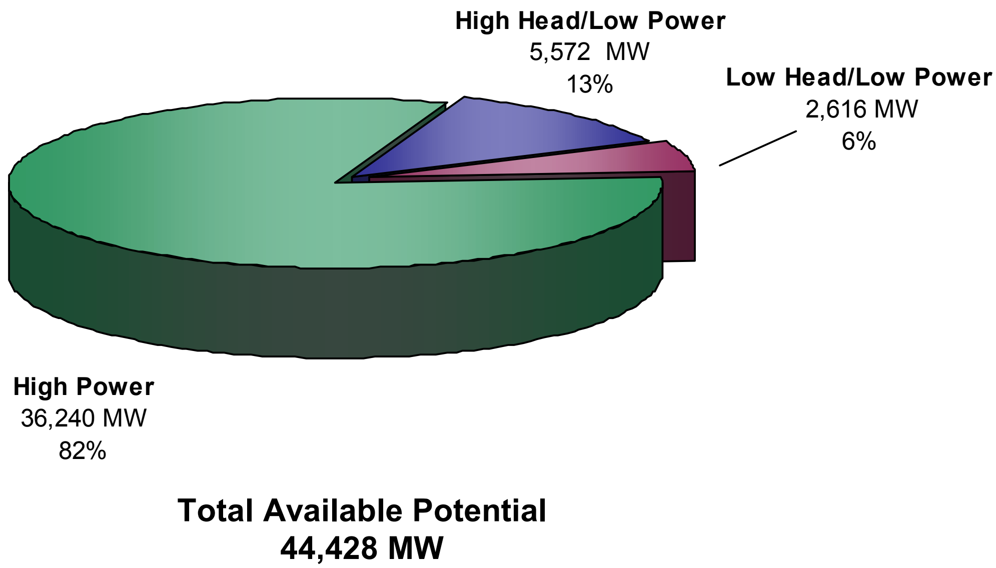


Figure A-93. Power class distribution of the available power potential (annual mean power) of water energy resources in the Alaska Region (HUC 19).

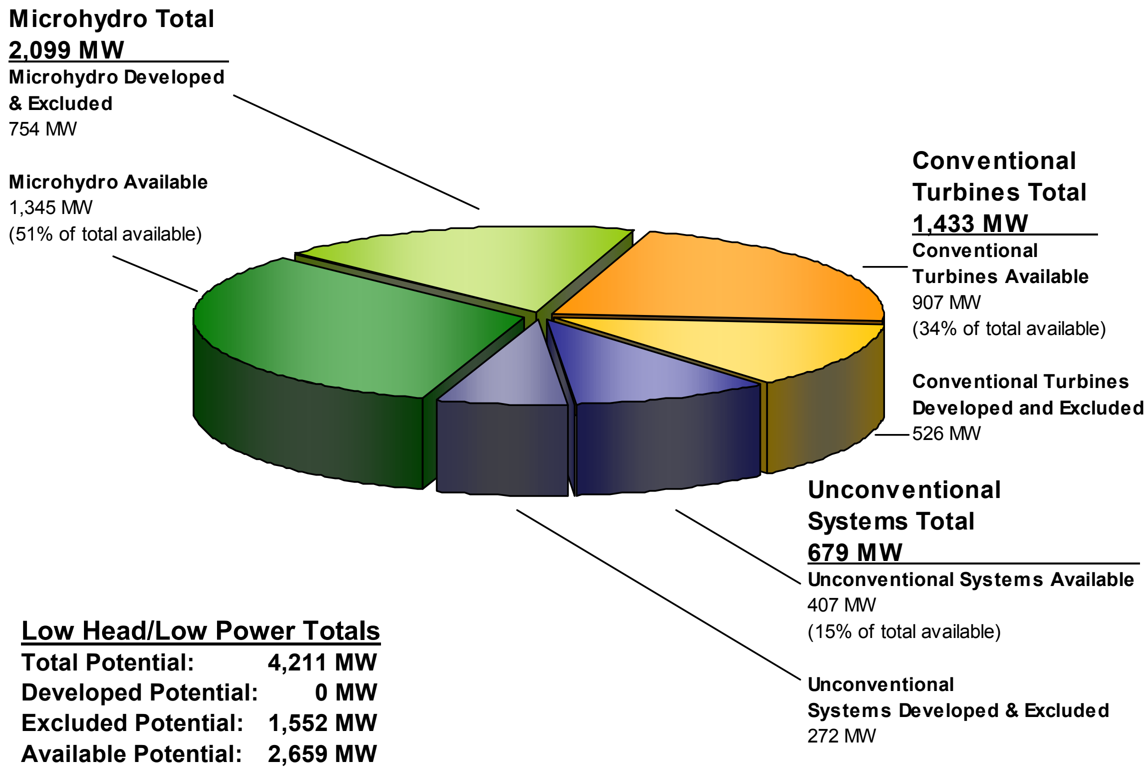


Figure A-94. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Alaska Region (HUC 19) among three low head/low power hydropower technology classes.

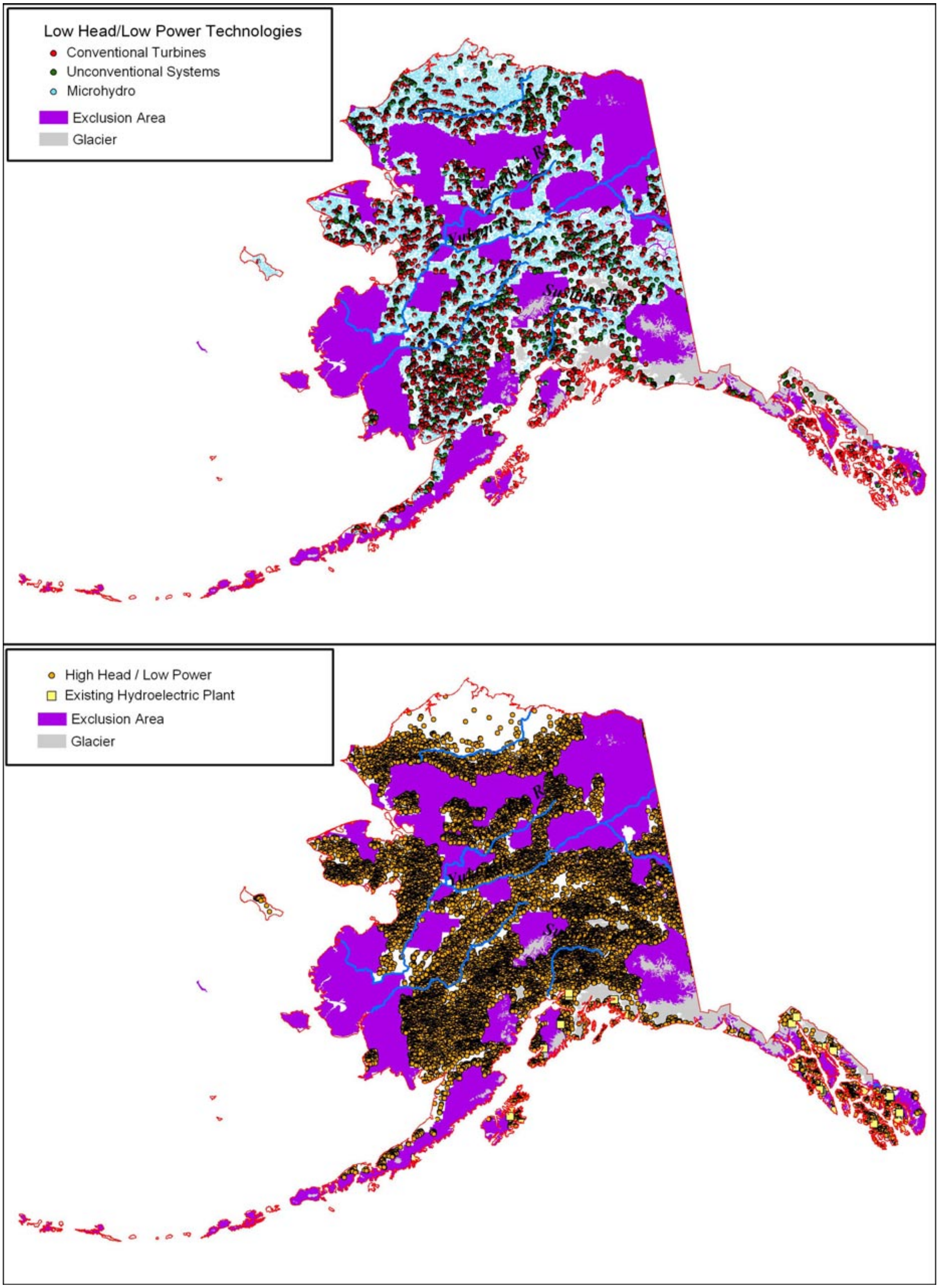


Figure A-95. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Alaska Region (HUC 19).

A.20 Hawaii Region

A.20.1 Region Description

The topographic and hydrographic features of the Hawaii Region are shown in Figure 96. The region is coincident with the State of Hawaii, the southernmost state in the U.S. Hawaii is composed of a northwest-to-southeast trending chain of eight volcanic islands near the middle of the Pacific Ocean. Hawaii is located approximately 2,200 miles southwest of the U.S. mainland.

Geologists believe that the islands formed by extrusion of molten rock from a stationary volcanic hot spot underneath the Pacific Plate. The oldest rocks, over 5 million years old, are found on Kauai, near the northwestern end of the island chain. Since that time, the movement of the Pacific Plate over the hot spot has created a succession of newer islands toward the southeast. The hot spot currently lies underneath the island of Hawaii, also known as the Big Island, which is the largest and newest of the island chain. Two volcanoes, Mauna Loa and Mauna Kea, reach elevations exceeding 13,000 feet. Mauna Loa most recently erupted in the 1940s, and a nearby volcano, Kilauea, began erupting in 1983. At present, the Big Island continues to increase in size as molten rock erupting from Kilauea flows to the sea to create additional land.

In addition, Haleakala, a volcano on the nearby island of Maui, last erupted in 1790 and is considered an active volcano. Volcanic activity has ceased on the other islands because motion of the Pacific plate has carried them too far away from the hot spot. Since the end of volcanic activity, erosion and subsidence has reduced the size of these islands. As a general rule, as one travels away from the volcanic hot spot under the Big Island, older islands are encountered, and island sizes decrease due to longer exposure to erosion and subsidence.

Hawaii's climate is generally warm and subtropical with highly variable levels of precipitation. Islands that have northern and eastern slopes exposed to open ocean receive abundant rainfall on those slopes, particularly at higher elevations. Annual precipitation levels in parts of Kawai exceed 400 inches per year, the highest levels in the U.S. These areas are covered with dense rain forest due to the wet climate. Other islands have drier climates because they lie in the rain shadow of nearby larger islands. In addition, the southern and western slopes of most islands are dry due to rain shadow effects. Landscapes in drier areas range from semi-arid grassland, to arid desert, including bare expanses of lava devoid of vegetation.

Because of their limited size, the islands lack large watersheds as found on the U.S. mainland. Instead, streams on the islands generally run outward in a radial pattern from volcanic summits and mountain ridges toward the sea. The largest streams with the highest flow levels are found on the wetter northern and eastern slopes of the islands with direct exposure to Pacific storms (Kauai, Oahu, Maui, and Hawaii).

A.20.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available water energy resources power potential (annual mean power) by power class
- Pie chart showing the developed, excluded, and available fractions of the total power potential (annual mean power)
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available power potential (annual mean power)
- Pie chart showing the fractions of the low head/low power power potential (annual mean power) corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power water energy resource sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power water energy resources.

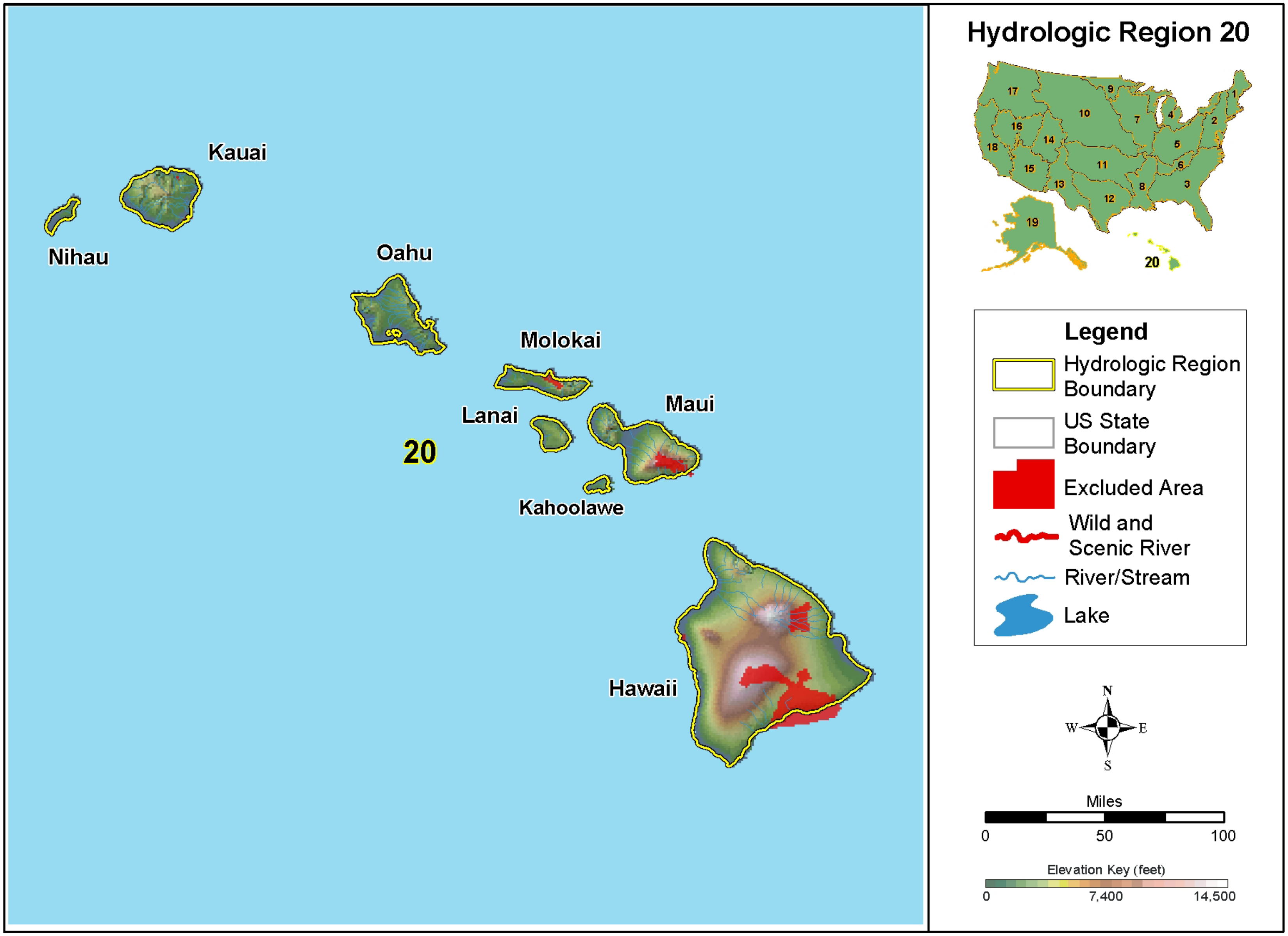


Figure A-96. Hawaii Region (HUC 20).

Table A-20. Summary of results of water energy resource assessment of the Hawaii Region (HUC 20).

Annual Mean Power (MW)	Total	Developed	Excluded	Available[a]
TOTAL POWER	**2,304**	**20**	**459**	**1,825**
TOTAL HIGH POWER	**2,138**	**17**	**439**	**1,682**
High Head/High Power	**2,138**	**17**	**439**	**1,682**
Low Head/High Power	**0**	**0**	**0**	**0**
TOTAL LOW POWER	**166**	**3**	**20**	**143**
High Head/Low Power	**156**	**3**	**19**	**134**
Low Head/Low Power	**10**	**0**	**1**	**9**
Conventional Turbine	1	0	0	1
Unconventional Systems	0	0	0	0
Microhydro	9	0	1	8

a. No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

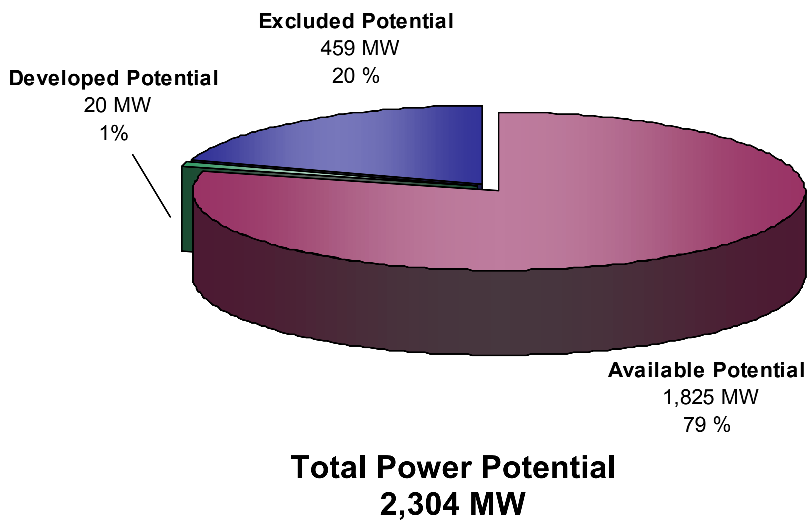


Figure A-97. Power category distribution of the total power potential (annual mean power) of water energy resources in the Hawaii Region (HUC 20).

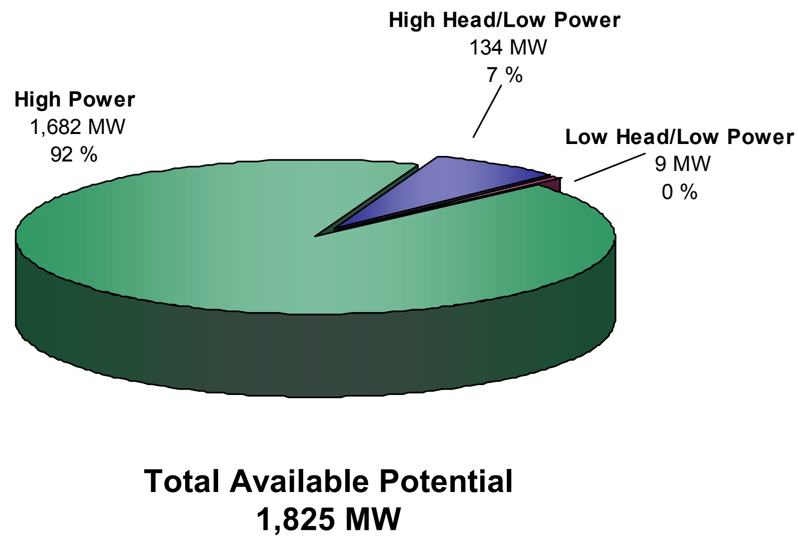


Figure A-98. Power class distribution of the available power potential (annual mean power) of water energy resources in the Hawaii Region (HUC 20).

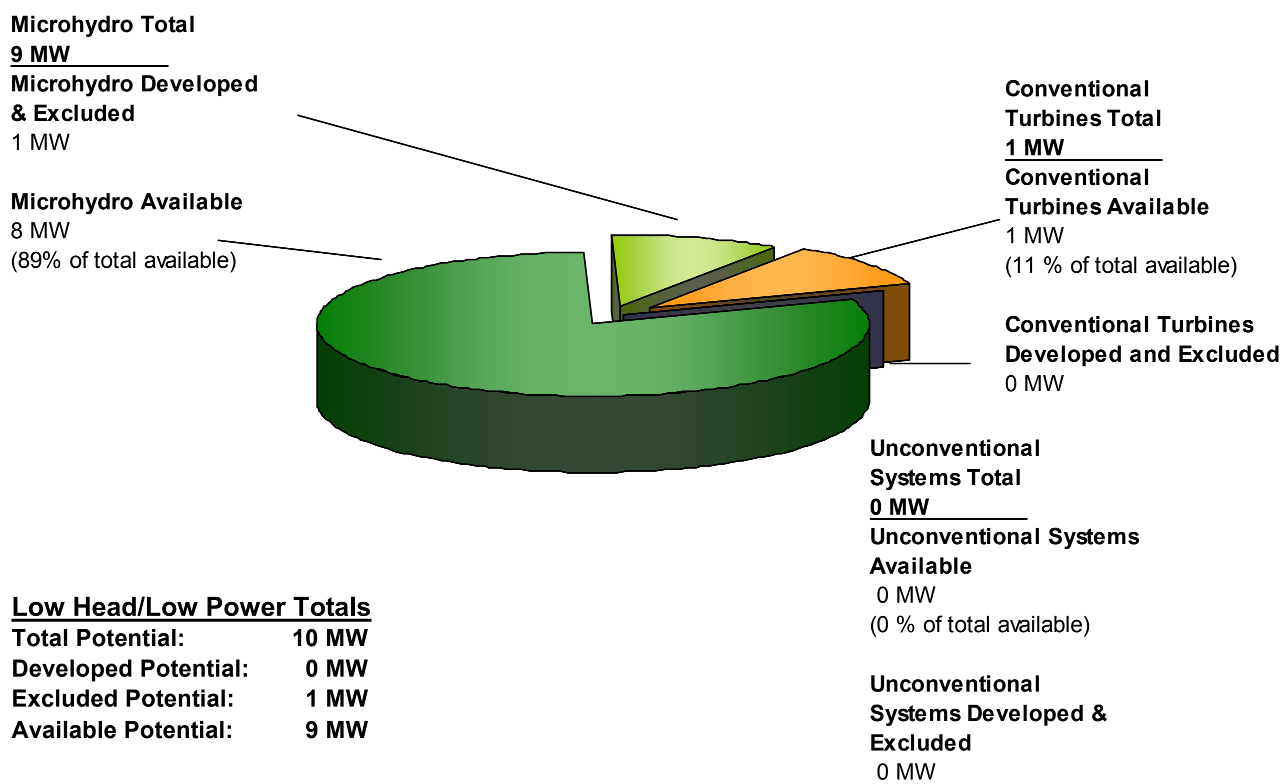


Figure A-99. Distribution of the low head/low power power potential (annual mean power) of water energy resources in the Hawaii Region (HUC 20) among three low head/low power hydropower technology classes.

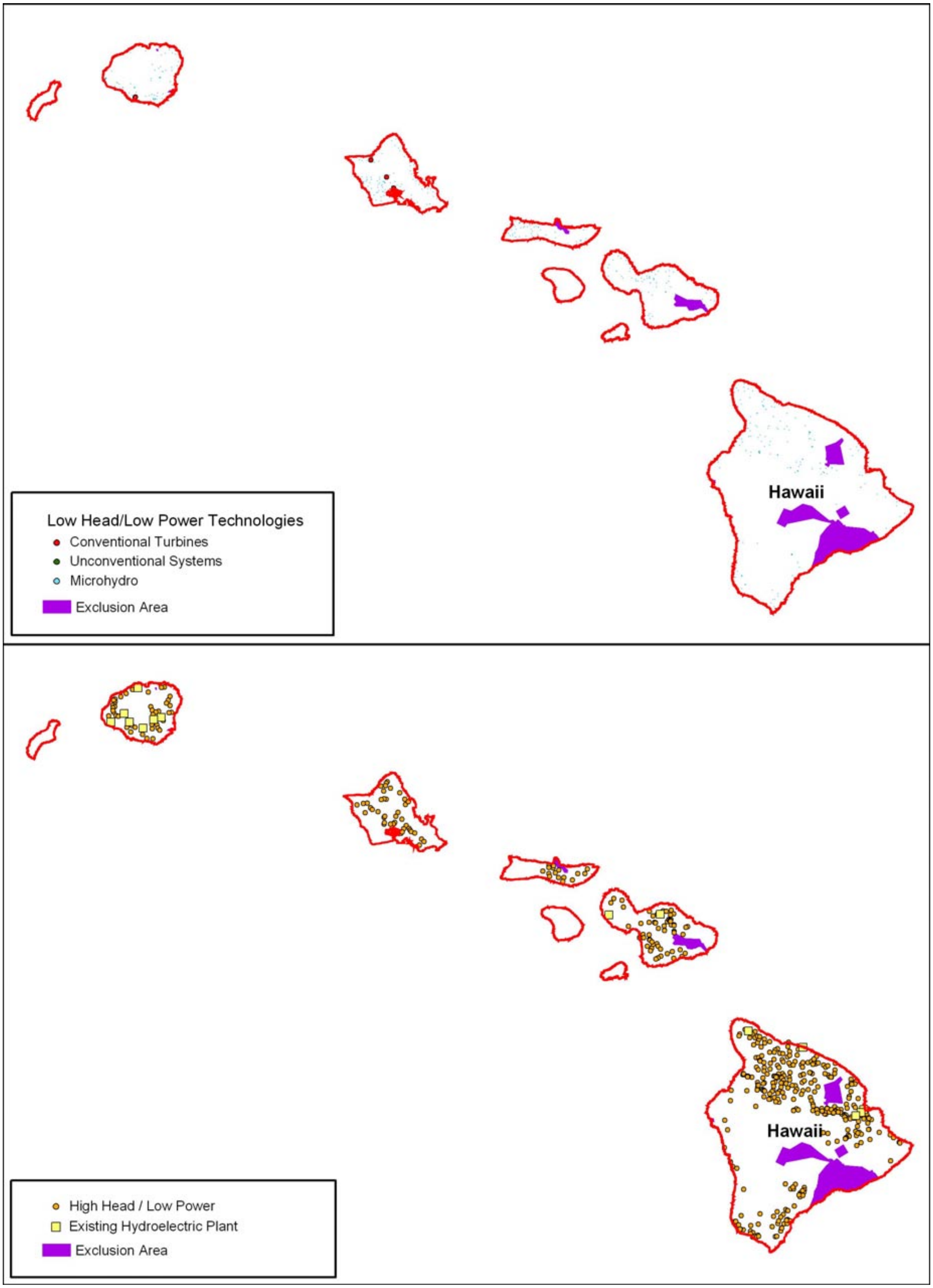


Figure A-100. Low head/low power and high head/low power water energy sites, and existing hydroelectric plants in the Hawaii Region (HUC 20).